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ABSTRACT

Findings of a review of research pertaining to federally subsidized school nutrition programs are presented in this report. The review of research, the first phase of the National Evaluation of School Nutrition Programs, is intended to provide guidance for the design of subsequent evaluation (including student, parent, and food administrator surveys) by describing school nutrition programs and their operations and by providing baseline information on nutritional status assessment, nutritional status of school-age children, program impact, and correspondences between targeting of program benefits and recipients' needs. Also identified are areas which need further investigation and methodological approaches most likely to increase knowledge of the programs and their effects. Chapter 1 in this first volume of the review provides the descriptive context for the studies reviewed in subsequent chapters, first presenting a history of the enabling legislation, then providing information on the organizational structure and operations of the programs. Chapter 2 describes methods for assessing the nutritional status of children and provides information for studies of program effects. Chapter 3 reviews studies of nutrition-related problems in American school-age children. Critical features of each study are described, discrepant findings are examined, and explanations of the differences found are offered. (RH)

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The National Evaluation of School Nutrition Programs

Review of Research–Volume 1

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NATIONAL EVALUATION OF SCHOOL NUTRITION PROGRAMS

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THE NATIONAL EVALUATION OF SCHOOL NUTRITION PROGRAMS

REVIEW OF RESEARCH - VOLUME 1

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The research reported herein was performed pursuant to a contract with the Office of Policy, Planning and Evaluation, Food and Nutrition Service, U.S. Department of Agriculture. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Therefore, points of view or opinions stated do not, necessarily, represent official USDA position or policy.

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APRIL 1981

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INTRODUCTION

Jean Wellisch

BACKGROUND

A review of research pertaining to the federally subsidized school nutrition programs was undertaken as the first phase of the National Evaluation of the School Nutrition Programs (NESNP). The findings of the review are presented in this report.

The NESNP is being conducted by System Development Corporation in conjunction with the Food and Nutrition Service (FNS) of the United States Department of Agriculture (USDA). The study, which began in October, 1979, is examining three of the child nutrition programs administered by FNS, namely, the National School Lunch Program (NSLP), the School Breakfast Progam (SBP), and the Special Milk Program (SMP). These three programs share the common legislative objective of safeguarding the health and well-being of the Nation's children. They have been authorized by the National School Lunch Act of 1946 and the Child Nutrition Act of 1966, as amended.

In addition to the review of research, the National Evaluation of School Nutrition Programs includes national surveys of approximately 8,000 public school students in grades 1 through 12, the parents of these students, and food administrators at the school, school district, and state levels. These three primary data collection and analysis efforts are intended to provide information needed to inform legislative decisions and operational directives concerned with the programs. Specifically, the objectives of the surveys are: to assess the current nutritional status of school children and the national need for the school nutrition programs; to determine whether the current levels and targeting of program benefits are appropriate for participants' needs; to assess the impact of the school nutrition programs on children, their families, schools, school districts, and states; to identify and document successful school nutrition projects, models, strategies, and procedures; and to develop forecasting models that can be used to predict participation rates in the school nutrition programs.*

The review of research, the first phase of the NESNP, is intended to provide guidance for the design of the subsequent parts of the evaluation (i.e., student, parent, and food administrator surveys), by describing the school nutrition programs and their operations and by providing baseline information on nutritional status assessment, on the nutritional status of school-age children, on program impact, and on the correspondence between targeting of program benefits and recipients' needs. The review identifies areas that need further investigation and also identifies methodological approaches that are most likely to increase our knowledge of the programs and their effects.

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*The objectives of the National Evaluation of the School Nutrition Programs coincide with many of the items in Senate Resolution 90 (Report No. 98-208), enacted on May 21, 1979, which requests the Secretary of Agriculture to

> ...conduct a study of the school nutrition programs administered under the National School Lunch Act and the Child Nutrition Act of 1966. The study is to include, but not be limited to, a consideration and assessment of (1) program costs, including procedures to implement uniform accounting methods for full cost accounting; (2) actions necessary to develop a national survey data base for these programs suitable for making projections of program participation and costs through simulations or other techniques; (3) the composition and income of families participating in the programs; (4) the effect of program participation, by income category, on the participants' nutrient intake and health; (5) whether the existing levels of program benefits are appropriate to the participants' needs; (6) whether the statements of policy contained in the National School Lunch Act and the Child Nutrition Act of 1966 should be modified; (7) the feasibility of using the school lunchroom as a nutrition education classroom; (8) the contribution of the programs to the agricultural economy, including commodity-by-commodity and regional analyses; (9) the options for dissemination of information on successful school food service operating procedures; (10) income verification procedures; and (11) the need for legislative changes to the items specified for consideration herein. The Secretary is requested to report on the progress of the study to Congress by January 31, 1980, and to submit a final report to Congress by March 31, 1981. (The NESNP will provide data to address Senate Resolution 90 items 2, 3, 4 and 5.)

REVIEW OF METHODOLOGY*

The review of research on the school nutrition programs involved six tasks: (1) proposing the questions that require answers, (2) identifying the research studies to be reviewed, (3) describing the methodology of each research study and the findings that bear on the questions, (4) critically analyzing and integrating the findings from studies that address the same question, (5) identifying information gaps and specifying needed research, and (6) reporting the results. Each of these tasks is discussed below.

Proposing the Questions

A basic tenet of any research, whether it is primary research or a critical review of the research literature, is that its usefulness is conditioned by the way it is conceptualized and the questions that it asks. As noted above, the major purpose of this review was to provide guidance for the three field surveys of the National Evaluation of the School Nutrition Programs and for future research that may be undertaken by USDA. Accordingly, as in assessing any program, the review focused upon what is known about the programs and their impacts and sought to identify areas in which further research is needed. For this investigation, we developed questions concerning the enabling legislation, objectives, and organization of the programs; the nature of the services and nutritional intervention provided by the programs; the effects of the programs on the nutritional status of participating students (including an assessment of the nutritional needs of the targeted groups and the various measures that have been used to determine nutritional status); the effects of the programs on participating families, schools and districts; and the extent to which targeting of benefits is appropriate to participants' needs. Figure 1 provides the list of the questions that directed the review and provided an outline for writing the report.

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*The methodology used for this review is very similar to that proposed by Jackson (1980) for the conduct of integrative reviews.

CHAPTER I: THE SCHOOL NUTRITION PROGRAMS--LEGISLATION, ORGANIZATION AND OPERATION

1. *HOW ARE THE SCHOOL NUTRITION PROGRAMS DESIGNED TO OPERATE?*

    A. *What Major Legislation Has Influenced the Operation of the Programs?*

    B. *What Are the Functions and Responsibilities of Federal, State and Local Agencies?*

    C. *How Are the Programs Funded?*

    D. *What Are the Reporting Requirements between Federal, State and Local Agencies?*

    E. *What Monitoring and Evaluation Activities Occur?*

    F. *What Functions Related to Food Procurement Occur at the Various Levels?*

    G. *What Outreach Functions Are Performed?*

    H. *Do the Programs Operate Differently in Private Schools Than They Do in Public Schools?*

    I. *How Many Students and Schools Participate in the Programs?*

CHAPTER II: METHODS FOR ASSESSING THE NUTRITIONAL STATUS OF CHILDREN

1. *WHAT METHODS HAVE BEEN USED TO ASSESS THE NUTRITIONAL STATUS OF CHILDREN AND WHAT ARE THEIR STRENGTHS AND LIMITATIONS?*

    A. *What Dietary Measures Have Been Used and What Are Their Strengths and Limitations?*

    B. *What Biochemical Measures Have Been Used and What Are Their Strengths and Limitations?*

    C. *What Anthropometric Measures Have Been Used and What Are Their Strengths and Limitations?*

Figure 1. Chapter Organization and Questions

CHAPTER III: THE NUTRITIONAL STATUS OF SCHOOL-AGE CHILDREN

1. *WHAT NUTRITIONAL PROBLEMS ARE FOUND AMONG SCHOOL-AGE CHILDREN, AND HOW ARE THESE PROBLEMS RELATED TO DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS?*
    - A. *What Dietary Deficiencies and/or Excessive Intakes of Nutrients and Other Dietary Constituents Have Been Identified as Nutritional Problems of School-Age Children?*
    - B. *What Nutrition-Related Conditions Have Been Identified by Biochemical Measures to be Problems for School-Age Children?*
    - C. *What Growth and Development Problems Have Been Identified by Anthropometric Measures as Nutritional Problems of School-Age Children?*
    - D. *What Clinical Signs of Nutritional Deficiencies Have Been Identified Among School-Age Children?*

CHAPTER IV: EFFECTS OF THE SCHOOL NUTRITION PROGRAMS ON STUDENTS AND FAMILIES, SCHOOLS AND DISTRICTS

1. *WHAT ARE THE EFFECTS OF THE SCHOOL NUTRITION PROGRAMS ON STUDENTS?*
    - A. *What Are the Effects of Participation on Nutritional Status?*
    - B. *What Are the Effects of Participation on Milk Consumption?*
    - C. *What Are the Effects of Participation on School Performance, Behavior, and Nutrition Knowledge?*
2. *WHAT ARE THE EFFECTS OF THE SCHOOL NUTRITION PROGRAMS ON FAMILIES?*
    - A. *What Are the Effects of Participation on Family Food Expenditures, Food Consumption, and Interactions Among Family Members?*
3. *WHAT ARE THE EFFECTS OF THE SCHOOL NUTRITION PROGRAMS ON SCHOOLS AND SCHOOL DISTRICTS?*

Figure 1. Chapter Organization and Questions (Cont'd)

CHAPTER V: TARGETING OF SCHOOL NUTRITION PROGRAM BENEFITS

1. *HOW ARE SCHOOL NUTRITION PROGRAM BENEFITS TARGETED?*

   A. *Do Family Size/Income Criteria Identify Children at Nutritional Risk?*

   B. *To What Extent Do Families Participate in More Than One Federal Assistance Program?*

2. *DO SCHOOL NUTRITION PROGRAMS MEET THE NUTRITIONAL NEEDS OF SCHOOL AGE CHILDREN?*

   A. *What Is the Nutrient Content of School Meals?*

   B. *Are School Meals Adequate for Nutrients That Are Deficient in School-Age Children?*

   C. *What Response Has USDA Made to the Findings of Nutritional Studies?*

CHAPTER VI: INFORMATION REQUIREMENTS

The final chapter identifies areas where more information is needed and indicates which of these areas will be addressed by the NESNP.

Figure 1. Chapter Organization and Questions (Cont'd)

Identifying Research For Review

The methods used to identify research studies for review are of prime importance. If the universe of studies on a given topic is small, or if all studies can be reviewed no matter the size of the universe, there is no problem. In most reviews, including this one, neither is the case; many studies have been conducted on various aspects of the school nutrition programs and it was not possible to search out and review all research that has ever been conducted. Moreover, even if all studies concerned with the programs could be reported, such a review would lose its usefulness by overtaxing the reader. Hence, criteria were established to ensure that the most important and current studies were selected for review. In the main, selected studies met the following criteria:

- The research must have been reported within the last 20 years.
- The research findings must have been published in official USDA publications, professional journals, or formal reports of investigations.
- The research must have been based on primary data collection.
- The research must be related to the programs or must provide information useful for evaluating the findings of research on the programs.
- The report on the research must contain a description of the research methods (sample, data collection and analysis procedures) that were used.

In a few cases, we included material in the review that did not meet one or more of these criteria. Such exceptions are indicated in the text.

While there have been many studies on various aspects of the school nutrition programs, few have been conducted under sufficiently controlled conditions and with large enough samples for their results to be generalizable to USDA programs across the nation. All studies that engaged in primary data collection, used systematic data collection procedures, and had large student samples were included in the review. While the large studies are well known and easily accessed, special search procedures were instituted for locating those that are smaller, and less well known. Computerized bibliographic searches were conducted, covering 1960 to the present, accessing the data bases of the Educational Resources Information Center (ERIC), the National Technical Information Service (NTIS), the Medical Literature Analysis and Retrieval System (MEDLARS), the Food Science and Technology Abstracts (FSTA), and AGRICOLA, the cataloging and indexing data base of the National Agricultural Library. Most of the studies identified in this way were small-scale evaluations of the school nutrition programs. In addition to the reports discovered in this manner, a few in-house USDA documents on studies in progress were provided by FNS, and still other studies were identified through citations in articles obtained through the computer search. Thus, while the studies discussed in the review do not exhaust the information that is available on the programs, we addressed all of the major studies and a large number of smaller ones that could be identified through our search techniques.

In addition to studies of the school nutrition programs, a sizable number of studies were reviewed that deal with material which--though not directly related to the programs--is needed to fully understand findings on program impact and targeting. These are studies that assess measures of nutritional status or identify the nutritional problems of American school-age children.

Describing Findings and Associated Methodology

As indicated above, one of the criteria for selecting the studies to be reviewed was that the reported research must contain a description of its methodology. It is important for reviewers and their audience to be able to establish a level of confidence in the findings. Unfortunately, reports vary considerably in the amount of detail provided about critical elements of the research, such as the hypotheses that were tested, the way in which the sample was selected, the instrumentation and data collection techniques, the analysis procedures, and the quality control procedures used throughout the study. To the extent possible, we present all the critical design elements of the studies. We also indicate where descriptions of these elements were omitted from the reviewed report.

Critically Analyzing and Integrating the Findings

Because the review was intended to provide guidance for field data collection and analysis in the NESNP as well as to point to future research that needs to be done, it was not enough to simply describe a number of studies that have dealt with a particular subject and report upon their findings. In general, reviews that are limited to abstraction and summarization of what is available in the literature are not particularly helpful; they place all of the analytic and interpretive burden on the reader. In this review, the methodology of each reported study is critiqued. When we compared two or more studies with different findings, we looked closely to see if factors associated with the samples, sampling errors, measures, or analytic techniques explained the differences. When such studies had similar findings, we looked to see if they shared a common methodological flaw.

We did not try to use statistical techniques to compare the findings from various studies. Because the studies addressed such a large number of topics, with methods ranging from systematic investigations of large groups to impressionistic case studies, many untenable assumptions regarding the nature of the data would have to be made in order to conduct a "meta-analysis" of the findings from several studies (Glass, 1976). On the whole such an exercise probably would have been more costly than it was worth. However, there are some areas, particularly those concerned with the effects of the school nutrition programs on the nutritional status of children, that could benefit from an analysis that compares the results from several studies. When the results from the field studies of the NESNP are available, it will be useful to compare its results statistically with those of the other large studies that have been conducted. However, even in this case, it may be more useful to conduct secondary analyses based on source data rather than to compare the summarized data published in reports.

We have tried to describe studies in sufficient detail to allow the reader to test our interpretations and conclusions. We have identified limitations of the research techniques used in these studies, but have also tried to avoid being hypercritical. Most of the studies reviewed here add to the store of information on the programs even when they have apparent methodological weaknesses. When congruent results are obtained from studies that do not share common defects, then we can be reasonably sure that these results add to our understanding of the observed phenomena.

Identifying Information Gaps and Specifying Research

The final analysis task in the review was to assess what is known with relative confidence from the research that has been examined on each topic, and to identify information that is not known, but is needed to improve the effectiveness of the school nutrition programs. The assessment of what is known depends largely on the confidence that we have in individual studies and on the congruence of findings from many studies. Where we have a question but no adequate answers, we have tried to indicate the kinds of research needed to fill the information gap.

We have tried to be realistic in making suggestions for the kinds of research that should be undertaken. We recognize that there are many factors that constrain research on the school nutrition programs. While we would all be much more confident about the effects of the National School Lunch Program

(NSLP) on the nutritional status of students if our information were obtained from studies that used a classical experimental design, there are reasons why such studies are often difficult to conduct. The widespread adoption of the NSLP by schools throughout the nation makes it highly unlikely that the treatment (NSLP) could be randomly assigned to schools. However, an experimental design probably could be used with the breakfast program, which is in only about one quarter of the schools. Many issues of interest concerning the school lunch program could be investigated with planned program variations. For instance, studies of the effects on participation of various meal types, delivery methods, etc., could use this approach. Planned variations could also be used to compare costs and plate waste associated with various meal types and delivery configurations.

Another type of constraint on the research concerns burden on subjects. For comparing participants in the programs with nonparticipants on a few dimensions of their nutritional status, for example, it may be desirable to do biochemical examinations of venous blood, but it is often impossible to obtain the cooperation of subjects when techniques are used which are perceived as invasive. Moreover, as these are school-based programs, there is a limit to the amount of interference and burden that school, district and state administrators will tolerate.

Finally, of course, there are cost considerations. Well planned, systematic, large-scale examinations of social interventions are expensive. So, in the interests of providing suggestions for research that are feasible, we have tempered our desire for the optimum by recognizing social, political and budgetary constraints.

Reporting the Results

The review of research is reported in six chapters, each focused on a major topic. Within the chapters the description of studies and discussion is organized around questions that are germane to the subject. (See Figure 1.)

Chapter I. The School Nutrition Programs--Legislation, Organization and Operation provides the descriptive context for the studies that are reviewed in subsequent chapters. First, a history of the enabling legislation is presented. Then information is provided on the organizational structure and operations of the programs. The information presented in this chapter is based on a variety of materials available in published documents--Federal legislation, Food and Nutrition Service (FNS) regulations, summaries of Congressional hearings and legislative histories, and periodic reports submitted to FNS by the states and regions. Interviews with FNS personnel helped supplement and clarify these materials.

As can be seen from the above list of information sources--which does not include any field studies--the orientation of this chapter is prescriptive, focusing on how the programs are supposed to operate rather than on how they actually operate. It would be interesting to have a complementary chapter that showed how actual operations deviate from prescribed ones, and early in the review process, we planned to include such an analysis. This task was abandoned, however, when we found that although there are many studies of program operations, they are almost all concerned with a limited set of operations in a single location. Consequently, it appeared that we would be spending a lot of resources to learn little more than that a need exists for a systematic study of program operations. Moreover, while of considerable interest, an extensive review of the research that has looked at program operations is somewhat tangential to the major emphases of this review: program effects and targeting of program benefits.

While the primary focus of Chapter I is on how the programs are supposed to operate, other chapters in the report refer to actual program operations. For example, the effects of participation in the programs on operations at the school and district levels are examined in Chapter IV, and Chapter V provides some information on various program operations in the context of program targeting.

Chapter II. Methods for Assessing the Nutritional Status of Children provides information for studies of program effects. In order to do a study of program effects on the nutritional status of children, it is necessary to select one or more criterion variables. Measures of nutritional status were used in all of the studies of effects of the programs on children that are reviewed in Chapter IV of this report; however, the tradeoffs considered in selecting the measures and the strengths and weaknesses of the ones finally selected are seldom discussed in the reports. Chapter II provides an analysis of the strengths and weaknesses of nutritional measures that will help the reader to understand why certain measures were selected in the reported studies, how these measures are generally used, and what limitations of the measures must be considered in evaluating the studies' results. In addition to helping interpret the results of past research, the evaluation of methods provided in Chapter II should be very useful to planners of future studies. Prior to this review no published comprehensive guide has been available for selecting the nutritional status measures to be used in large-scale surveys of school-age children. Chapter II describes the dietary, biochemical, and anthropometric measures that have been used to assess nutritional status, the field procedures that are required for collecting data, and the particular conditions for which each measure is most useful. Studies are reviewed that have tried to assess the validity and reliability of the measures. And finally, the various kinds of measures are compared on the basis of four criteria: reliability, validity, cooperation of subjects, and feasibility/cost.

Chapter III. The Nutritional Status of School-Age Children is also a resource for understanding the evaluative research reviewed in Chapters IV and V in this document, and for guiding future research, particularly in the area of targeting. In this chapter, we review studies that used one or more of the measures described in Chapter II to identify nutrition-related problems in American school-age children. Critical features of each study are described, including sample characteristics, selected measures, analysis procedures, and results. The review examines discrepant findings and tries to explain the differences that were found. One important thrust of the review is to determine if particular nutritional problems are found with greater frequency than expected in particular socioeconomic groups. This is critical for the targeting of benefits, since it is often assumed that poor children are at the greatest nutritional risk, and that if school meals are offered at free and reduced prices, they are more likely to participate in the programs.

Chapter IV. Effects of the School Nutrition Programs on Students, Families, Schools and Districts describes the few large and several smaller studies that have investigated the impact of the school nutrition programs. Most of these studies are concerned with program effects on participating children. Relatively few studies have looked at the impact on families, and even fewer have tried to determine the effects of program participation on schools and districts. Much of the review in Chapter IV is concerned with an analysis of the methodologies used in the reported studies, with particular attention to sampling, design, and analysis.

Studies that examined program impact on students have investigated effects on nutritional status (as measured by one or more of the indicators described in Chapter II). In addition, some of the studies investigated effects on school performance and on behavior as measured by teacher ratings, grades and test scores. Several studies investigated milk consumption in relation to participation in the school nutrition programs, lactose and milk intolerance, and the type of milk offered. This topic was included for review because of the possibility that milk may make the greatest single contribution to the nutrient value of the school meals.

Studies of effects on families concern the effects of participation on food-related behaviors--food expenditure, food consumption, and interaction among family members--that is associated with eating together.

As mentioned above, little has been reported about program effects on schools and districts. In particular we were interested in finding studies that looked at the effects of changes in the level of federal subsidization on institutional participation and the quality of the food service, but we were unable to identify studies of this kind. We did find many studies that examined the effects of operational and procedural variations on costs and food quality. A few of these studies are reviewed to illustrate the types of research that have been done on this topic. While these studies don't answer the question of how the programs affect schools and districts, the examination of operational practices that will lead to greater cost-effectiveness in delivering the school nutrition services is also of interest.

Chapter V. Targeting of Program Benefits reviews two aspects of targeting: The first examines how the school nutrition program benefits are targeted, with emphasis on the effectiveness of using family size/income criteria to obtain the participation of children at greatest nutritional risk. Included in this first approach are studies that examine the extent to which families who participate in the school nutrition programs also participate in other federal assistance programs, such as food stamps and Aid to Families with Dependent Children.

The second approach to targeting examines the correspondence between the nutritional needs of school-age children and the programs' nutritional benefits. In Chapter III, as described above, studies that try to identify nutrition-related problems of school-age children are reviewed with special emphasis on problems that are more likely to be found in particular socioeconomic groups. That discussion of the nutritional needs of school-age children, and of the nutrition-related problems that have been identified, is used to help assess the findings of studies on the nutrient content of school meals reviewed in Chapter V.

One aspect of the second approach to targeting that is particularly interesting concerns program responsiveness--the extent to which the programs can be modified as new information becomes available on nutritional needs and on the factors that affect participation. Chapter V examines this aspect of targeting with a review of recent changes to the programs which were instituted by USDA to make the targeting of benefits more appropriate to the needs of school children.

Chapter VI. Information Requirements summarizes what is known about the school nutrition programs, what is not known, and what kinds of research are needed to provide a more complete picture of program effects and the appropriateness of program targeting. The chapter synthesizes the high points of the critical reviews contained in the preceding chapters and draws conclusions regarding the types of research that should be undertaken.

Some of the requirements for future research are already being met in the National Evaluation of the School Nutrition Programs (NESNP). As will be recalled from our earlier discussion, one objective of this review of research was to guide the design for primary data collection and analysis in the NESNP. Chapter VI highlights design decisions that were made in sampling, in the selection of nutritional status measures, and in the plans for analysis, in direct response to the findings of this review.

SUGGESTIONS FOR THE READER

The review of research presented here is comprehensive, detailed, and voluminous. It is unlikely that most readers will have the need or the patience to examine the whole report assiduously. Many readers will want to use this report as a resource for identifying the studies and findings that are related to particular aspects of the school nutrition programs. For this reason, we have provided a reference list that includes all studies that were examined, whether or not they are referred to in this report. The review provides a number of signposts to help readers easily find the discussions in which they are interested. Also, summary information is provided throughout the report.

The general topics, major questions, and subquestions that are addressed in each chapter are shown in Figure 1. This should help guide the reader to topics of interest. Each chapter in the report begins with a summary of the answers to the questions that are addressed in that chapter. The final chapter of the report, Chapter VI, highlights the major gaps in our information that were disclosed by this review of research.

SUMMARY OF CHAPTER I. THE SCHOOL NUTRITION PROGRAMS--LEGISLATION, ORGANIZATION AND OPERATION

This chapter provides a general description of the operations of the three school nutrition programs: The National School Lunch Program (NSLP), the School Breakfast Program (SBP), and the Special Milk Program (SMP). The State Administrative Expense (SAE) and Food Service Equipment Assistance (FSEA) programs are also discussed. Information presented here has been drawn from a variety of sources including current legislation, program regulations, legislative histories, Congressional summaries, program data, relevant literature, and interviews with the program staff. The programs are described as they are intended to operate; the discussion does not address the extent to which the actual implementation of the programs differs from the legislative and regulatory intent. The major legislative trends that have influenced the operation of the programs are discussed and the current programs are summarized in terms of specific issues. The following research question guided the review:

HOW ARE THE SCHOOL NUTRITION PROGRAMS DESIGNED TO OPERATE?

This question has been further particularized in several subquestions. The subquestions are presented below along with a summary of findings:

A. *What Major Legislation Has Influenced the Operation of the Programs?*

Throughout the 1930s, the federal government purchased farm commodities for distribution to schools as a means of absorbing farm surpluses and supporting agricultural incomes. The practice was formalized with the passage of the National School Lunch Act in 1946. The Act authorized financial assistance to public and private schools operating non-profit lunch programs. Thus, the goals of the lunch program were: (1) to distribute surplus commodities and support farm income; and (2) to safeguard the health of school children. With the passage of the Child Nutrition Act of 1966 several changes were introduced into the program. Initially, both the breakfast and milk programs were authorized only on a preliminary basis, but subsequently received permanent authorization. The Child Nutrition Act also strengthened the lunch program by authorizing funds for the Non-Food Assistance program and by initiating the State Administrative Expense program. The programs continued to expand through the mid-1970s. Uniform national eligibility guidelines for free and reduced-price meals were introduced in 1970, so that more children in need of the program, as newly defined by economic criteria, would receive meals. Provisions were made for semi-annual adjustments of the reimbursement rates.

In recent years, improved management and fiscal austerity have been emphasized in most federal programs. The Assessment, Improvement, and Monitoring System (AIMS) was introduced to improve control over federal expenditures for the nutrition programs. The programs are currently faced with demands for control of spending and increased accountability to Congress.

B. *What Are the Functions and Responsibilities of Federal, State and Local Agencies?*

At the national level, the Secretary of Agriculture, under statute, administers the school nutrition programs. This authority, in turn, has been delegated to USDA's Food and Nutrition Service (FNS) which assumes the overall administration of the programs. FNS establishes program policies, implements legislation, and provides funds to states. The School Programs Division (SPD) of FNS manages the programs with support from several other FNS offices and USDA agencies. The Food and Nutrition Service and the School Programs Division comply with requests for program information from other federal agencies such as the General Accounting Office (GAO) and the Office of Management and Budget (OMB).

At the regional level, FNS Regional Offices (FNSROs) provide technical assistance to the state agencies (SAs), monitor the state agencies by conducting Management Evaluations, and directly administer the programs in some private schools. The regional offices also review annual state plans. The state agencies administer the programs within the states and monitor the performance of school food authorities (SFAs). The state agencies provide supervisory assistance to SFAs in technical areas as needed and establish record-keeping and reimbursement systems. SAs are also responsible for preparing the annual state plan and submitting the plan to FNS for approval. School food authorities, usually at the school district level, are responsible for the administration of the program in one or more schools and have the legal authority to operate a school feeding program. SFAs administer the programs at the school level typically by purchasing food, accepting donated commodities, maintaining the necessary food service facilities, approving eligible students for free and reduced-price meals, maintaining financial records, and monitoring school food service operations. Finally, the schools are primarily responsible both for preparing and serving food to children and for establishing a system that prevents children who receive free or reduced-price meals from being identified by their peers.

C. *How Are the Progams Funded?*

Federal payments to schools for the NSLP, SBP, and SMP are provided by means of performance funding. Under lunch and breakfast programs, school food authorities earn a basic payment for every meal served to children and an additional payment for meals served to children who are eligible for free or reduced-price meals. A similar payment structure operates for the milk program: school food authorities earn a standard payment for each half-pint of milk served to paying children, while the full cost of the milk is reimbursed for all children who are eligible to receive free milk.

The annual value of donated commodities to be distributed to states is based on the number of meals served during the previous school year. States are responsible for distributing the commodities to SFAs; SFAs, in turn, may choose the commodities they will receive. State Administrative Expense (SAE) funds are allocated to states for their expenses such as salaries, fringe benefits, training and supplies. Food Service Equipment Assistance funds, also, are awarded to states, and states, in turn, use these funds to assist SFAs in purchasing equipment.

D. *What Are the Reporting Requirements Between Federal, State and Local Agencies?*

Program data are collected at the school and SFA level and are subsequently reported in various formats to the state. Schools provide information on student payments, the number of meals served by price category and costs associated with meal production. These are furnished to the SFA, where the data are used to prepare reimbursement claims and other reports. For the months of October and March, additional information such as enrollment, attendance and free and reduced-price meal eligibility and approval status are collected and reported by the SFAs. Reimbursement claims and other reports are sent to the states where the data are summarized on standard USDA forms. Reports are generally submitted to the FNS Regional Offices. At the national level, the data are reviewed for trends and are used for program management purposes.

E. *What Monitoring and Evaluation Activities Occur?*

There are currently five monitoring and evaluation activities for the program: Management Evaluations (MEs), audits, supervisory assistance, the Assessment, Improvement and Monitoring System (AIMS), and program evaluation research. Management Evaluations are conducted annually by the regional offices; they are designed to assess state performance in administering the programs by examining operations at the state, SFA and school levels. The

MEs compare program activities at these levels with the objectives outlined in the state plan. Specific evaluation guidelines are developed annually by FNS and have recently focused on policies concerning free and reduced-price eligibility criteria, reimbursement methods, and nutritional issues. ME reports are transmitted to the national office by the regional offices.

Two types of audits are conducted: (1) USDA, Office of the Inspector General (OIG), conducts audits annually that generally cover all regions, one-third of the states, and an appropriate sample of SFAs (the size of the sample is determined annually by OIG); and (2) in addition, OMB requires that audits be conducted within all SFAs every two years by state or outside auditors. Findings are reviewed at the federal level. Supervisory assistance is provided by state agencies to SFAs and schools as needed. States include a plan for supervisory assistance in the annual state plan and outline the technical areas where such assistance may be required. Visits to SFAs and schools allow states to provide assistance in assuring compliance with federal regulations and guidelines.

USDA has recently implemented the Assessment, Improvement, and Monitoring System (AIMS), which requires the states to monitor SFAs and schools in terms of five specified performance standards. Finally, FNS also performs evaluations of its programs, demonstrations, and pilot projects.

F. *What Functions Related to Food Procurement Occur at the Various Levels?*

Food for use in the programs is acquired either through donation of commodities or direct open-market purchase. Commodities are bought at the federal level and are allocated to states on the basis of the number of meals served during the previous year. The federal government arranges for the delivery of commodities to state warehouses or delivery points. The state may then store or process the food, or arrange for immediate transport to SFAs. Some states arrange for processing to increase the acceptance of particular commodities by the SFAs. The SFAs may refuse the offered commodities, but the states are under no obligation to replace refused commodities. Except for donated commodities, most food is purchased by local SFAs or individual participating schools.

G. *What Outreach Functions Are Performed?*

FNS has used program outreach efforts to expand the numbers of both schools and children participating in the school nutrition programs, with special emphasis on providing program benefits to needy children. At the national and regional levels, FNS conducts public information activities to assist the states in their outreach efforts.

The state agencies attempt to increase participation in the lunch and breakfast programs through outreach activities such as sending program materials and information to nonparticipating schools, and visiting targeted schools. SFAs encourage children eligible for free and reduced-price status to participate by sending the eligibility criteria to parents and to the local media.

H. *Do the Programs Operate Differently in Private Schools Than They Do in Public Schools?*

With regard to school nutrition programs, private schools differ from public schools in only one major way: in those few states where law prohibits state agency involvement with private schools, the programs are administered directly by the FNS regional office. In such states, the private schools report to the regional offices, and the regional offices prepare annual plans for the private schools. The distribution of donated commodities, however, is handled by the appropriate state agency for these schools. In all other states, private school programs are administered by the state agency in a manner similar to that for public schools.

I. *How Many Students and Schools Participate in the Programs?*

Participation is defined by FNS in two ways: (1) the number of schools operating programs, and (2) the average number of meals served under the programs. School participation in the lunch program has been increasing steadily in recent years, from 75 percent of schools in 1972 to about 88 percent in 1975. Preliminary program data for 1978-1979 indicate that about 94 percent of public schools participated in the lunch program, and that within participating schools, lunches were served to about 60-62 percent of the average daily attendance. For the same school year, about 26 percent of all schools participated in the breakfast program, and breakfasts were served to about 22-23 percent of the average daily attendance in those schools. The Special Milk Program operates in over 80 percent of schools, and serves an estimated 10 million half-pints of milk daily. In almost all cases, the milk program exists in schools that also have the lunch program. Participation rates in the programs have continued to rise in recent years despite declining school enrollments.

Table I-1 highlights the major functions and responsibilities that are discussed in this summary.

Table I-1. Major Program Functions at the Various Levels*

Program Level	Functional Responsibilities	Reporting Responsibilities/ Funds Flow	Monitoring Responsibilities
FNS (Washington)	1) Establishes policy and develops regulations. 2) Monitors performance.	1) Reviews report forms - FNS47, FNS10, FNS13, and SF269. 2) Authorizes U.S. Treasury to make funds available.	1) Resolves audits. 2) Reviews Management Evaluations.
FNS Regional Office (FNSRO)	1) Liaison with states. 2) Provides assistance to state agencies. 3) Monitors state agencies. 4) Administers programs in non-public schools.	1) Reviews and edits reports prepared by state agencies - FNS47, FNS10, FNS13 and SF269; authorizes Federal Reserve Bank to issue Letter of Credit. 2) Reviews FNS806 reported directly to FNSRO by non-public schools/SFA; authorizes U.S. Treasury to issue Treasury checks for non-public SFAs that are administered by the FNSRO. (This applies only to those non-public schools administered directly by the FNSRO; all non-public schools administered by the state agency report as above, see number 1).	1) Conducts Management Evaluations of the state agencies annually. 2) Reviews audits of the SA which are conducted by the Office of the Inspector General. 3) Reviews and approves state plans. 4) Monitors programs in non-public schools.
State Agency (SA)	1) Provides assistance to SFAs. 2) Monitors performance at SFA level.	1) Reports number of meals served monthly as well as the number of participating schools and enrollment twice annually to FNSRO (FNS10). 2) Reports revenues and costs annually to FNSRO (FNS13). 3) Reports expenditures by programs quarterly to FNSRO (SF269). 4) Reports annually the number of participating and non-participating schools to FNSRO (FNS47). 5) Draws on Letter of Credit from Federal Reserve Bank. 6) Reports use of funds to FNSRO (SF183).	1) Reviews and assesses performance of SFA. 2) Implement AIMS; this is a uniform reporting system to be used by SFAs.
School Food Authority (SFA)	1) Administers programs at school level. 2) Procures, stores, and transports food. 3) Announces free and reduced-price eligibility criteria, reviews applications, and determines eligibility. 4) Maintains fiscal records.	1) Reports number of meals served to SA. 2) Reports cost data to SA. 3) Reports number of schools participating in each program to SA. 4) Reports enrollment data to SA. 5) Reports number of eligibles to SA. 6) Submits reimbursement voucher to SA; receives reimbursements from the SA. 7) For non-public schools administered by the FNSRO, costs, income, and participation data are reported directly to FNSRO (FNS806). (All non-public schools administered by the SA as above, see numbers 1 through 6.)	1) Assures that participation and cost data are collected. 2) Monitors schools (at the option of each SFA.)
School	1) Serves meals. 2) Prevents overt identification of free and reduced-price eligibles.	1) Collects data on meals served for SFA. 2) Collects data on student meal payment for SFA. 3) Collects free and reduced-price applications from parents for SFA.	

**All reporting forms refered to in this table are included in Appendix A of this paper.*

CHAPTER I. THE SCHOOL NUTRITION PROGRAMS--LEGISLATION, ORGANIZATION AND OPERATION

Kathryn Nelson

INTRODUCTION

This chapter describes the operations of the school nutrition programs: National School Lunch Program (NSLP), School Breakfast Program (SBP), and the Special Milk Program (SMP). The purpose and use of State Administrative Expense funds and Food Service Equipment Assistance funds are also examined. The major pieces of legislation that have affected the programs are summarized, and the various functions and responsibilities of the different program levels--i.e., federal at the national and regional levels, state, school food authority (SFA), and school--are discussed.* The information presented here is based on primary references, such as the legislation and regulations, in order to draw a picture of the programs as they should operate. Summaries of Congressional activities and legislative histories of the program were also reviewed. Furthermore, in order to understand program subtleties, current program information pertinent to the issues discussed in this chapter was collected in interviews with FNS staff in regional offices and in Washington. Additional information was provided by staff from state agencies and School Food Authorities (SFAs). Special reports and studies are referenced in this chapter only to supplement the information provided by FNS.

The following sections describe the programs as they are mandated to operate by legislation, regulations, and guidelines. The extent to which the implementation of the programs differs from their mandates is not addressed here. Various program functions, responsibilities and procedures are outlined, but this discussion should not be interpreted to mean that the programs are actually operating to the full extent implied in the law and related regulations, nor does it mean that sufficient staff are available to implement the intended functions fully. This discussion describes the programs as they appear in legislation, regulations, and guidelines, and will serve as a baseline for comparison with empirical data that are being collected in the Food Administrator Survey of the National Evaluation of School Nutrition Programs.

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*Since this review was written, numerous changes in the school nutrition programs have been made as a result of the Omnibus Budget Reconciliation Act of 1981 (PL 97-35). Provisions of the Act that affect the school nutrition programs are shown in Appendix A, Volume 2, page 649.

This chapter is intended to answer the following research question:

HOW ARE THE SCHOOL NUTRITION PROGRAMS DESIGNED TO OPERATE?

In order to answer this broad question, more specifically focused questions were generated to guide our review:

A. *What Major Legislation Has Influenced the Operation of the Programs?*

B. *What Are the Functions and Responsibilities of Federal, State and Local Agencies?*

C. *How Are the Programs Funded?*

D. *What Are the Reporting Requirements Between Federal, State and Local Agencies?*

E. *What Monitoring and Evaluation Activities Occur?*

F. *What Functions Related to Food Procurement Occur at the Various Levels?*

G. *What Outreach Functions Are Performed?*

H. *Do the Programs Operate Differently in Private Schools Than They Do in Public Schools?*

I. *How Many Students and Schools Participate in the Programs?*

The ensuing discussion presents findings from the review that address these questions.

A. *What Major Legislation Has Influenced the Operation of the Programs?*

The federal government has had a long history of involvement in nutrition in the schools; such intervention has been legislatively authorized since 1935. (See Table I-2 for a summary of the major legislation affecting the school nutrition programs.) The federal government began donating surplus food for use in elementary and secondary schools during the 1930s as a way of absorbing surplus farm commodities, increasing farm incomes, and bringing nutritious meals to needy children. In 1935, funds were authorized under Section 32 of PL 74-320, the Agricultural Adjustment Act, specifying that up to 30 percent of the U.S. Customs' receipts be allocated to the Secretary of Agriculture for various purposes, including the encouragement of domestic consumption and the reestablishment of farmers' purchasing power. Section 32 thus became the first authorization for the use of federal funds for food donations to schools.

During the 1930s and early 1940s the purchase and distribution of surplus commodities was expanded, but the major step in formalizing locally-initiated school food service was the passage of the National School Lunch Act of 1946 (PL 79-396). As a result of this law, the Consumer and Marketing Service, a predecessor agency to the Food and Nutrition Service, was authorized to begin the National School Lunch Program (NSLP). Two major objectives of PL 79-396 were (1) to safeguard children's health by providing them with nutritious foods, and (2) to support farm incomes by increasing food consumption. The first goal of safeguarding children's health has been addressed by offering nutritious food during the school day. To attain this goal, the National School Lunch Program, under the supervision of the Secretary of Agriculture,

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Table I-2. Major Legislation Affecting the School Nutrition Programs

DATE	LEGISLATION	SYNOPSIS
1935	Agricultural Adjustment Act (PL 74-320)	Authorized the use of Customs' receipts to purchase farm surplus commodities and to donate such commodities to schools.
1946	National School Lunch Act (PL 79-396)	Established national program which formalized locally-initiated school food service programs.
1954	Agricultural Act of 1954 (PL 83-690)	Authorized annual appropriation to encourage consumption of fluid milk in schools.
1966	Child Nutrition Act (PL 89-642)	Initiated the breakfast and milk programs and strengthened the lunch program by providing non-food assistance funds and the state administrative expense program.
1970	Amendments to the National School Lunch Act (PL 91-248)	Established uniform national eligibility guidelines for free and reduced-price meals.
1971	Amendments to the National School Lunch Act (PL 92-32)	Broadened the selection criteria for schools receiving funds to initiate the breakfast program.
1972	Amendments to the National School Lunch Act (PL 92-433)	Extended the breakfast program for three years and made it available to all schools requesting it.

Table I-2. Major Legislation Affecting the School Nutrition Programs (Cont'd)

DATE	LEGISLATION	SYNOPSIS
1973	Amendments to the National School Lunch Act (PL 93-150)	Established minimum reimbursement rates to be adjusted semiannually.
1975	Amendments to the National School Lunch Act (PL 94-105)	Made permanent the breakfast program; broadened eligibility criteria for reduced-price meals; introduced the Type A offer-versus-serve lunch.
1977	Amendments to the National School Lunch Act (PL 95-166)	Authorized the Nutrition Education and Training Program; revised the formula for state administrative expenses.
1978	Amendments to the National School Lunch Act (PL 95-627)	Authorized the use of funds for AIMS; established the eligibility criteria for free lunches; eliminated separate cost accounting procedures for breakfast and lunch programs; increased FSEA funds; and broadened definition of especially needy schools.

provided financial aid to public and private schools that operated non-profit lunch programs. Meals were designed to meet specified nutritional requirements. They were made available to children in participating schools, and were offered free or at reduced prices to children from families determined to be in need by local school authorities.

In the Agricultural Act of 1954 (PL 83-690), consumption of fluid milk in schools was encouraged by a permanent annual appropriation to the Commodity Credit Corporation, which distributed commodities to states for redistribution to schools.

Apportionments for the states were based on the number of school-age children in each state and on the state's need for assistance; the latter figure being derived from the relation of the per capita income in the U.S. to the per capita income in the state. In 1962 this formula was amended so that funds were apportioned to states based on the number of children who participated in the program during the previous year and the state's need for assistance. Special cash assistance, in addition to the basic federal payments, was authorized for schools that drew their attendance from low-income areas, although funds were not made available until 1966.

The Child Nutrition Act (PL 89-642) was passed by Congress in 1966 to expand and strengthen food service programs for children. This occurred at a time when legislative and public attention focused on the improvement and expansion of many social programs. The Breakfast and Special Milk programs were formally authorized under this legislation, and the administration of the lunch program was strengthened by the authorization of non-food equipment funds as well as funds for state administrative expenses.

The 1966 legislation also initiated a pilot school breakfast program, which provided states with funds for the development of the program. The breakfast program was modeled after the lunch program, with one major distinction: the program was primarily directed to poor areas and to schools where children had to travel long distances. In addition, the Child Nutrition Act formally recognized and extended until 1970 the Special Milk Program, which had been in existence in various forms since 1954.

To strengthen the lunch program, the Child Nutrition Act legislated a permanent authorization for the Non-Food Assistance Program. This program was first authorized and funded under the National School Lunch Act of 1946, but no additional funds were appropriated between 1946 and the Child Nutrition Act of 1966. The Child Nutrition Act was intended to provide financial assistance to public and non-profit schools in poor areas so that they could acquire the equipment needed to store, transport, prepare and provide food to children served by the school lunch program. The Act also authorized federal payment to state agencies for their administrative and supervisory expenses in implementing school nutrition programs and giving technical assistance to school districts; however, such funds were not appropriated until 1969. The Child Nutrition Act directed that all federal school food programs be administered by the Secretary of Agriculture, who would be responsible for the conduct, supervision, and expansion of these programs. Thus, programs administered by the Department of Agriculture became a fundamental instrument for offering nutritious meals to all children, with some benefits targeted specifically to needy children.

The decade of the seventies was a time of rapid expansion for all of the programs, with Congressional legislation providing the impetus for this growth. Not only did the number of schools administering the programs increase, but increasing numbers of children participated in the programs, particularly the children of the poor families to whom benefits were specifically targeted.

In 1970, Congress directed the Secretary of Agriculture in PL 91-248 to establish uniform national guidelines to determine eligibility for free and reduced-price meals. These guidelines replaced the widely varying local definitions of "needy" families. Eligibility standards for the school programs were set according to family size and income, and schools were required to announce publicly the eligibility requirements for these programs at the beginning of each school year.

The School Breakfast Program was another focal point of USDA's expansion efforts throughout the 1970s. In 1971 (PL 92-32), the selection of schools to receive program funds was expanded so that schools were given priority where there was a special need for improving the nutrition and dietary practices of children of working mothers and children from low-income families. In 1972 (PL 92-433), the breakfast program was extended for three years and was made available to all schools requesting it. The program was finally made permanent in 1975 under PL 94-105, and Congress stated that the program should be made available in all schools where it was needed to provide adequate nutrition.

In 1973, Congress established minimum reimbursement levels for the school nutrition programs under PL 93-150; these rates were to be adjusted semiannually to account for inflation. Additional funding was provided for the Food Service Equipment Assistance Program (formerly the Non-Food Assistance Program) and for the State Administrative Expenses.

The 1975 amendments (PL 94-105) to the National School Lunch Act broadened the eligibility criteria for reduced-price meals. Eligibility for reduced-price meals was set at 195 percent of income poverty guidelines. Consideration of special hardship conditions was also allowed in evaluating applications for reduced-price meals.

At the same time that program coverage was being expanded, efforts were also made to improve the quality of the meals served, under the reasoning that if meals were more acceptable to children, less food would be wasted, and children would be encouraged to eat a nutritious diet. Also under PL 94-105, high school students were allowed to choose three of the five meal components of the reimbursable meal pattern and still be considered as participants in the program (this is commonly referred to as the Type A offer-versus-serve meal). In 1977, the Nutrition Education and Training Program was initiated by PL 95-166 to disseminate nutrition information to school-age children and to train school food service providers in nutrition and meal service planning. This same legislation revised the formula for allocating funds for state administrative expenses to the states for such expenses as salaries, office equipment and staff training incurred in providing technical and supervisory assistance to the school food authorities.

More recently, Congress has been concerned with fiscal austerity and program accountability. In the school nutrition programs, this concern has focused attention on developing and improving fiscal responsibility and management procedures. In 1978 (PL 95-627), Congress directed that some of the available State Administrative Expense funds be allocated to states to improve management in state administration of the program, i.e., to establish better systems for auditing, monitoring and reviewing management procedures. The Assessment, Improvement and Monitoring System (AIMS) provides an example of how the funds are used. The regulations for AIMS require state agencies to identify management and operational problems and institute corrective actions. To identify such problems, states must carry out a required number of reviews of school food authorities in order to determine if specified performance standards are being met. To help state agencies defray the additional administrative reporting, record-keeping and personnel costs, AIMS regulations provide for the allocation of a specified portion of SAE discretionary funds to be used for these expenses. The use of SAE funds to ensure greater fiscal responsibility is part of USDA's response to "recent studies by the Department's Office of the Inspector General and the General Accounting Office that have raised significant questions regarding the effectiveness of present school feeding program reimbursement claiming procedures, monitoring systems, and corrective action activities" (AIMS, Draft Impact Analysis).

PL 95-627 initiated other changes in the program as well. The legislation removed the flexibility of the states to vary the eligibility standards for free meals by requiring states to set the standards at 125 percent of the Secretary's guidelines. Earlier, in 1975, the eligibility for the reduced-price lunch program had been set at 195 percent of the Secretary's guidelines. PL 95-627 also increased the equipment assistance funding and broadened the definition of especially needy schools that can be awarded additional funds by the states.

A further effort in the direction of greater fiscal responsibility involves stricter audit requirements. These requirements for the school nutrition programs were modified in 1975-76 to conform with federal management circulars issued by the Office of Management and Budget, which require that grant programs be audited every two years. Other recent FNS regulations also reflect the concern for greater fiscal control over the programs: School Food Authority procurement procedures are now required to conform to the procurement procedures used by the state agency, and criminal penalties have been prescribed for fraud and misuse of funds in connection with food programs. Increased regulatory controls have been imposed on food service management companies. Such measures indicate an increasing insistence that the school nutrition programs be monitored carefully to ensure that the use of federal funds conforms to current regulations and laws.

Discussion

The legislative history of the school nutrition programs reveals an initial concern with providing price support structures for the benefit of the agricultural economy. During the period of rapid program expansion in the late 1960s and 1970s, the program emphasis shifted to a concern with providing nutritious meals for all of the nation's children with some benefits targeted specifically to the needy. Recent legislative and regulatory initiatives indicate that fiscal austerity and program accountability are areas of current concern. Cost-saving efforts through responsible fiscal management such as AIMS will attempt to monitor more closely the expenditure of federal dollars. Further, the school nutrition programs have experienced cuts in their reimbursements. Decreases in the reimbursement rate for the lunch and milk programs in the FY 1981 budget are the first major cuts in the appropriations for the programs. It is likely, therefore, that legislation, at least in the near future, will continue to reflect Congressional concern with fiscal controls and accountability.

B. *What Are the Major Functions and Responsibilities of Federal, State and Local Agencies?*

This section first summarizes the organizational context in which the school nutrition programs operate and then discusses the functions and responsibilities of the different program levels: federal (national and regional), state, school food authority, and the local school. Information in this section was derived from legislation and current regulations, meetings with regional and federal FNS staff, Management Evaluation guidelines, the Summary of Management Evaluation and Office of Investigation Findings for 1979, and other U.S. Department of Agriculture documents on the various food programs at the SFA and school level.

The Federal Level

At the federal level, the Secretary of Agriculture has been given the authority under statute to administer the breakfast, lunch, and milk programs. While USDA is solely responsible for the overall administration of the programs, other federal agencies such as the General Accounting Office (GAO) and the Office of Management and Budget (OMB) may make specific requests for program information. OMB may require information for the executive branch, while GAO conducts studies and investigations of particular issues for Congress. The U.S. Treasury, upon notification from USDA, makes program funds available to the states through the Regional Reserve Banks.

Within USDA, the authority to administer the programs has been delegated by the Secretary to the Food and Nutrition Service (FNS). The mission of FNS is to help combat poverty-related hunger and malnutrition in this country through the administration of food stamps; food distribution programs; school lunch, breakfast, and milk programs; child care food programs; and other child nutrition and special feeding programs. FNS is responsible for implementing program legislation; establishing regulations, policies, and guidelines; monitoring program performance; and providing program and administrative funds to states. Although FNS is responsible for the overall administration of the programs, other offices within USDA, which are mentioned in this chapter, have very specific responsibilities in regard to the school nutrition programs. For example, the Food Safety and Quality Service (FSQS), the Agricultural Stabilization and Conservation Service (ASCS), and the Commodity Credit Corporation (CCC) participate in the selection and purchase of commodities to be donated for use in the school nutrition programs. In addition, the Office of the Inspector General (OIG) conducts audits and investigations of the programs. These offices are illustrated in Figure I-1, which is an organizational chart of USDA.

Within FNS, the School Programs Division (SPD), located under the Deputy Administrator for Special Nutrition Programs, manages the day-to-day operations of the school nutrition programs (See Figure I-2). For example, SPD prepares program guidance on specific issues such as defining the focus of the management effort. Other FNS divisions that have a role in the administration of the programs are also illustrated in Figure I-2. The Nutrition and Technical Services Division (NTSD) provides technical support in the area of nutrition to the school programs. The Food Distribution Division (FDD) determines the amounts of commodities to be donated nationally

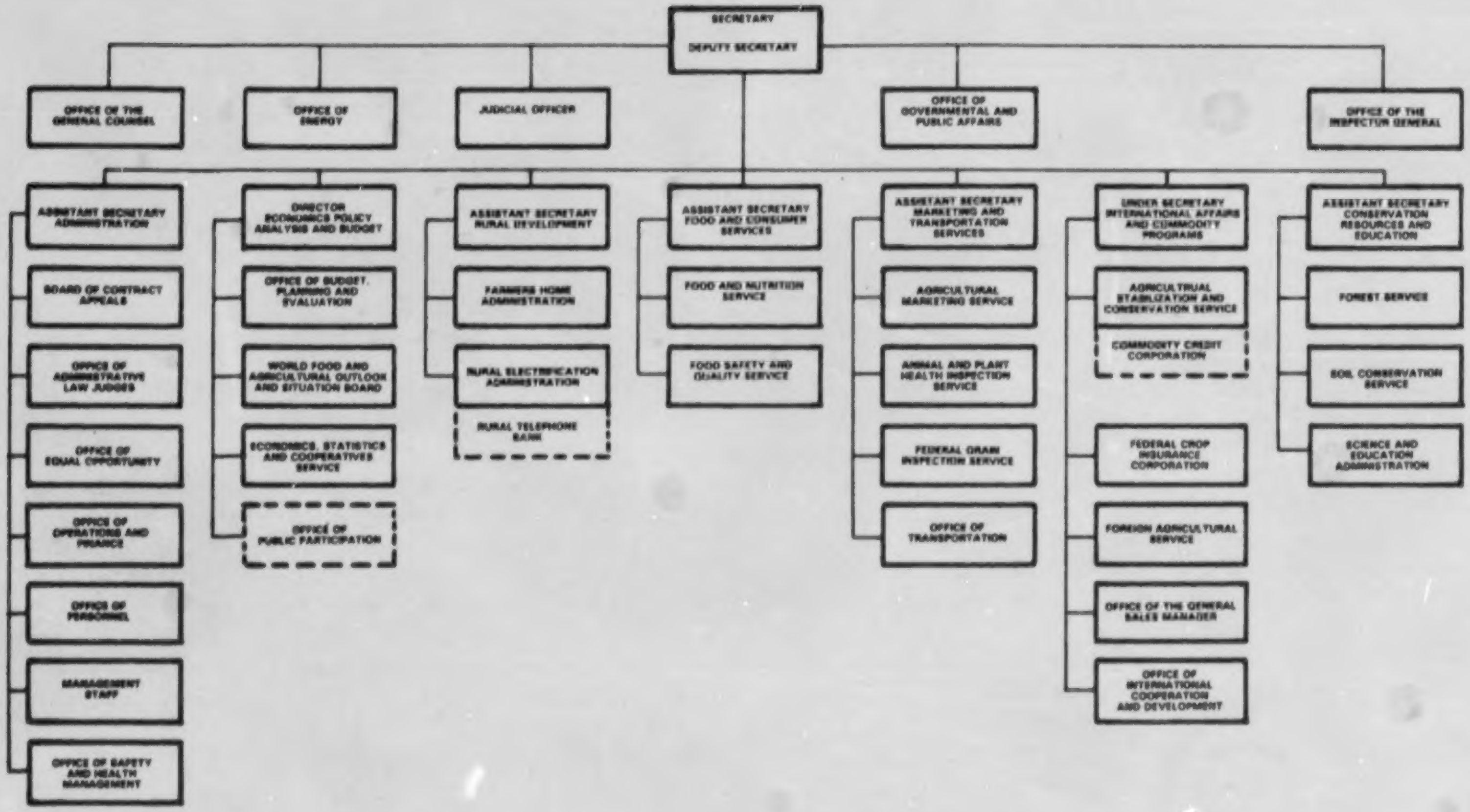
SECRETARY
DEPUTY SECRETARY
OFFICE OF THE GENERAL COUNSEL
OFFICE OF ENERGY
JUDICIAL OFFICER
OFFICE OF GOVERNMENTAL AND PUBLIC AFFAIRS
OFFICE OF THE INSPECTOR GENERAL
ASSISTANT SECRETARY ADMINISTRATION
BOARD OF CONTRACT APPEALS
OFFICE OF ADMINISTRATIVE LAW JUDGES
OFFICE OF EQUAL OPPORTUNITY
OFFICE OF OPERATIONS AND FINANCE
OFFICE OF PERSONNEL
MANAGEMENT STAFF
OFFICE OF SAFETY AND HEALTH MANAGEMENT
DIRECTOR ECONOMICS POLICY ANALYSIS AND BUDGET
OFFICE OF BUDGET, PLANNING AND EVALUATION
WORLD FOOD AND AGRICULTURAL OUTLOOK AND SITUATION BOARD
ECONOMICS, STATISTICS AND COOPERATIVES SERVICE
OFFICE OF PUBLIC PARTICIPATION
ASSISTANT SECRETARY RURAL DEVELOPMENT
FARMERS HOME ADMINISTRATION
RURAL ELECTRIFICATION ADMINISTRATION
RURAL TELEPHONE BANK
ASSISTANT SECRETARY FOOD AND CONSUMER SERVICES
FOOD AND NUTRITION SERVICE
FOOD SAFETY AND QUALITY SERVICE
ASSISTANT SECRETARY MARKETING AND TRANSPORTATION SERVICES
AGRICULTURAL MARKETING SERVICE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
FEDERAL GRAIN INSPECTION SERVICE
OFFICE OF TRANSPORTATION
UNDER SECRETARY INTERNATIONAL AFFAIRS AND COMMODITY PROGRAMS
AGRICULTRUAL STABILIZATION AND CONSERVATION SERVICE
COMMODITY CREDIT CORPORATION
FEDERAL CROP INSURANCE CORPORATION
FOREIGN AGRICULTURAL SERVICE
OFFICE OF THE GENERAL SALES MANAGER
OFFICE OF INTERNATIONAL COOPERATION AND DEVELOPMENT
ASSISTANT SECRETARY CONSERVATION RESOURCES AND EDUCATION
FOREST SERVICE
SOIL CONSERVATION SERVICE
SCIENCE AND EDUCATION ADMINISTRATION

Figure I-1. Organization Chart of the U.S. Department of Agriculture

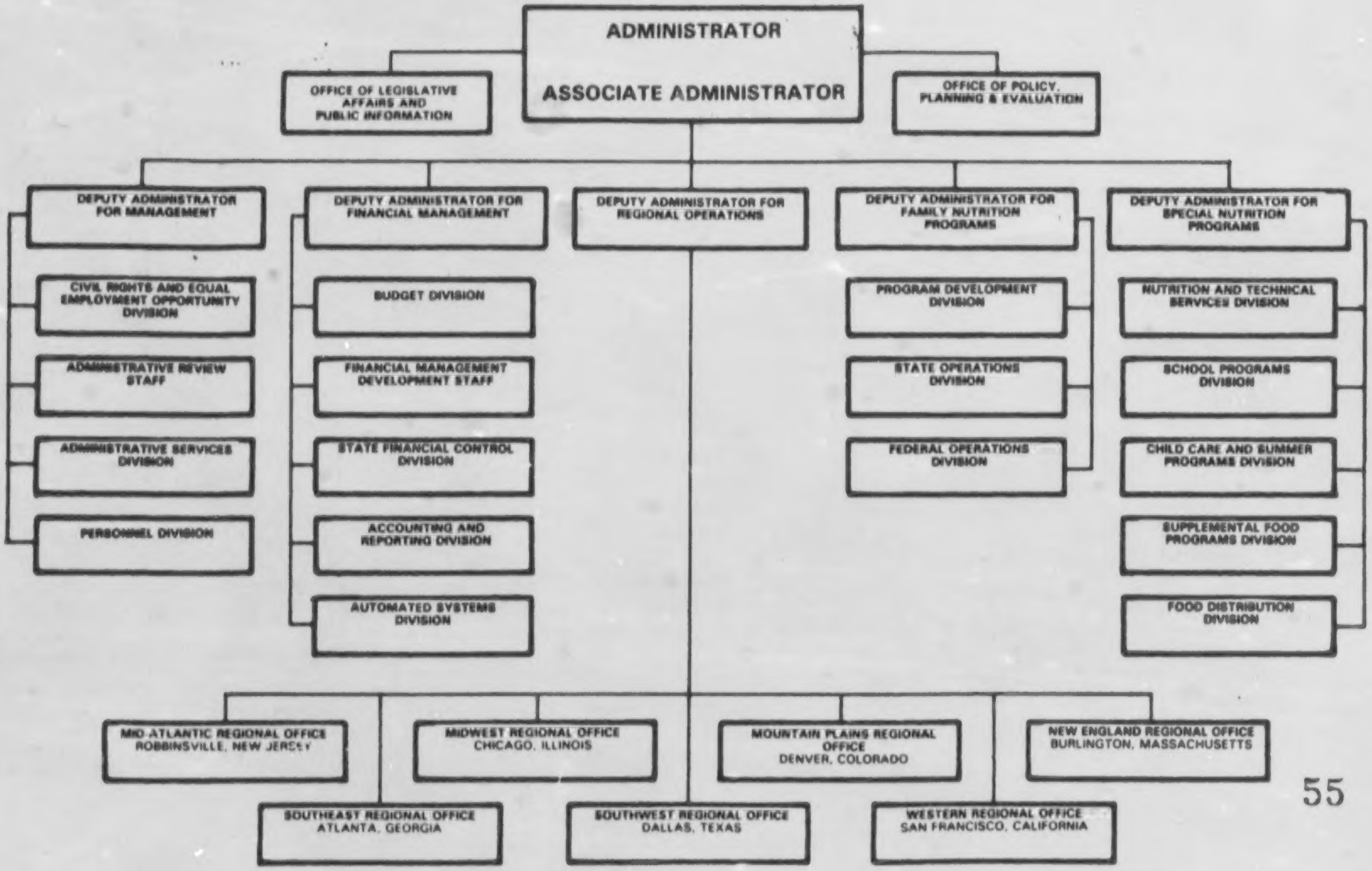
ADMINISTRATOR
ASSOCIATE ADMINISTRATOR
OFFICE OF LEGISLATIVE AFFAIRS AND PUBLIC INFORMATION
OFFICE OF POLICY, PLANNING & EVALUATION
DEPUTY ADMINISTRATOR FOR MANAGEMENT
CIVIL RIGHTS AND EQUAL EMPLOYMENT OPPORTUNITY DIVISION
ADMINISTRATIVE REVIEW STAFF
ADMINISTRATIVE SERVICES DIVISION
PERSONNEL DIVISION
DEPUTY ADMINISTRATOR FOR FINANCIAL MANAGEMENT
BUDGET DIVISION
FINANCIAL MANAGEMENT DEVELOPMENT STAFF
STATE FINANCIAL CONTROL DIVISION
ACCOUNTING AND REPORTING DIVISION
AUTOMATED SYSTEMS DIVISION
DEPUTY ADMINISTRATOR FOR REGIONAL OPERATIONS
DEPUTY ADMINISTRATOR FOR FAMILY NUTRITION PROGRAMS
PROGRAM DEVELOPMENT DIVISION
STATE OPERATIONS DIVISION
FEDERAL OPERATIONS DIVISION
DEPUTY ADMINISTRATOR FOR SPECIAL NUTRITION PROGRAMS
NUTRITION AND TECHNICAL SERVICES DIVISION
SCHOOL PROGRAMS DIVISION
CHILD CARE AND SUMMER PROGRAMS DIVISION
SUPPLEMENTAL FOOD PROGRAMS DIVISION
FOOD DISTRIBUTION DIVISION
MID-ATLANTIC REGIONAL OFFICE ROBBINSVILLE, NEW JERSEY
MIDWEST REGIONAL OFFICE CHICAGO, ILLINOIS
MOUNTAIN PLAINS REGIONAL OFFICE DENVER, COLORADO
NEW ENGLAND REGIONAL OFFICE BURLINGTON, MASSACHUSETTS
SOUTHEAST REGIONAL OFFICE ATLANTA, GEORGIA
SOUTHWEST REGIONAL OFFICE DALLAS, TEXAS
WESTERN REGIONAL OFFICE SAN FRANCISCO, CALIFORNIA

Figure I-2. Organization Chart of the Food and Nutrition Service

in a school year and coordinates the allocation of donated commodities among states. The State Financial Control Division and the Accounting and Reporting Division monitor, respectively, the states' use of the Letters of Credit which authorize states to draw on Treasury funds and the claims adjustments filed by the states. The operations of the seven FNS Regional Offices (FNSROs) are also administered within FNS. The Office of Policy, Planning, and Evaluation (OPP&E) is responsible for program development, evaluation of FNS programs, and analysis of policy issues related to the school nutrition programs. Several of these offices work together cooperatively in preparing program guidance and other materials for use by states, SFAs, and schools; for example, SPD, OPPE, and NTSD help to establish the nutritional standards for meals, specifying components and quantities to be served.

Figure I-3 illustrates the interrelations of the agencies at various levels that share responsibility for the school nutrition programs. In addition to the national-level offices involved in the administration of the programs, the regions, states, school food authorities, and schools have important roles. These are depicted graphically in the flow chart of functions and responsibilities found in Figure I-3, and are outlined in the following text.

The Regional Level

The major functions of the Food and Nutrition Service Regional Office (FNSRO) are to provide technical assistance to the state agencies, monitor the state agencies, and administer programs in private schools where state laws prohibit the state agency from doing so. The FNSRO supervises and oversees the managerial and administrative functions of the state agency. It conducts an annual Management Evaluation of the performance of the state agency by assessing the program operations and financial management of the school food authorities. In performing this task, the FNSRO also examines audit findings, past Management Evaluation reports, and supervisory assistance findings

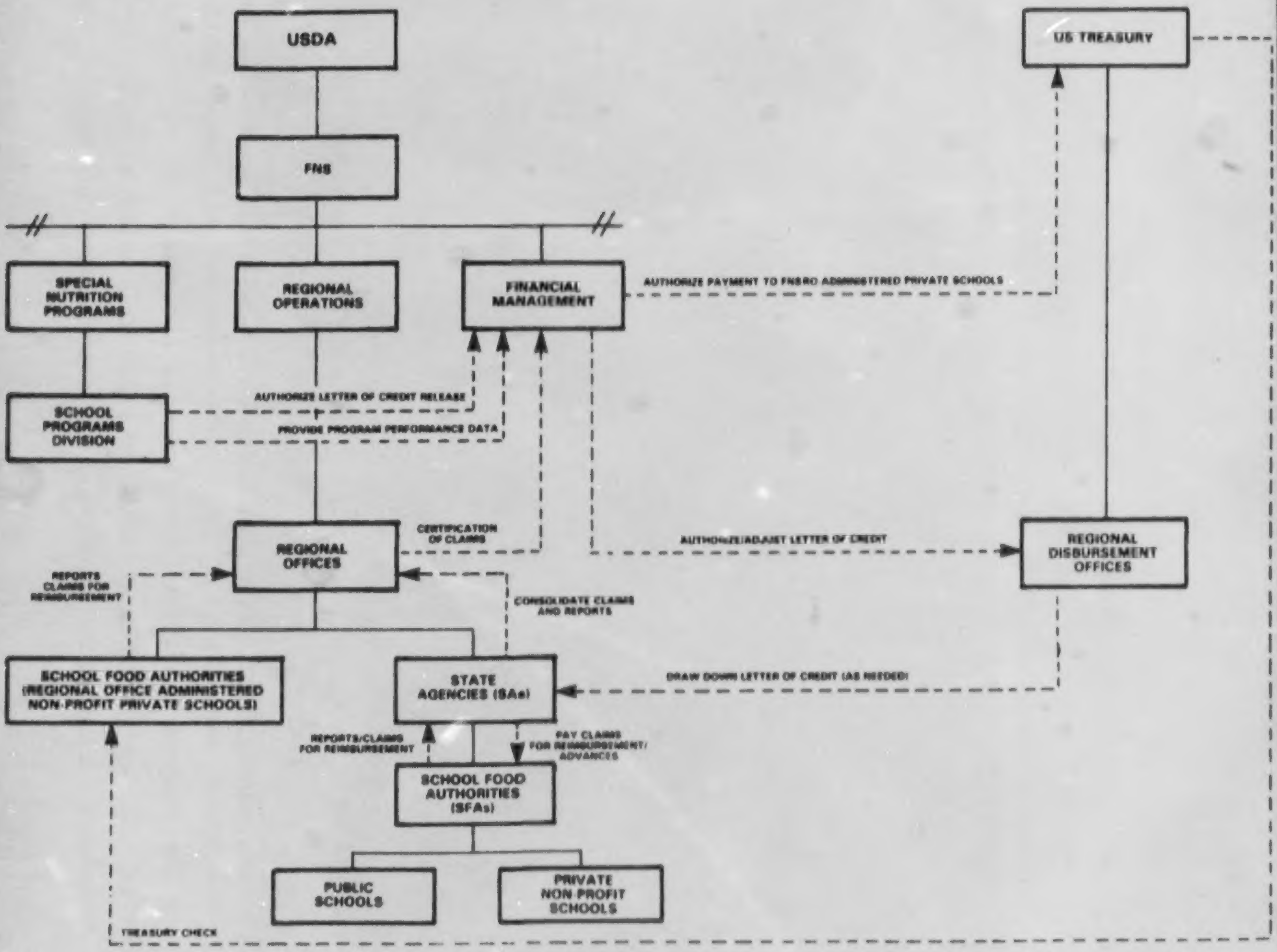
USDA
US TREASURY
FNS
SPECIAL NUTRITION PROGRAMS
REGIONAL OPERATIONS
FINANCIAL MANAGEMENT
AUTHORIZE PAYMENT TO FNSRO ADMINISTERED PRIVATE SCHOOLS
SCHOOL PROGRAMS DIVISION
AUTHORIZE LETTER OF CREDIT RELEASE
PROVIDE PROGRAM PERFORMANCE DATA
REGIONAL OFFICES
CERTIFICATION OF CLAIMS
AUTHORIZE/ADJUST LETTER OF CREDIT
REGIONAL DISBURSEMENT OFFICES
REPORTS CLAIMS FOR REIMBURSEMENT
CONSOLIDATE CLAIMS AND REPORTS
SCHOOL FOOD AUTHORITIES (REGIONAL OFFICE ADMINISTERED NON-PROFIT PRIVATE SCHOOLS)
STATE AGENCIES (SAs)
DRAW DOWN LETTER OF CREDIT (AS NEEDED)
REPORTS/CLAIMS FOR REIMBURSEMENT
PAY CLAIMS FOR REIMBURSEMENT/ ADVANCES
SCHOOL FOOD AUTHORITIES (SFAs)
PUBLIC SCHOOLS
PRIVATE NON-PROFIT SCHOOLS
TREASURY CHECK

Figure I-3. Flow of Funds and Reporting-School Nutrition Programs

(Audits, Management Evaluations, and supervisory assistance are discussed in detail in Section E). The FNSRO also reviews and approves the annual state plan for child nutrition operations submitted by the state agency.

The State Level

The state agency (generally the Department of Education) administers school nutrition programs within the state in accordance with federal regulations and policies. It also monitors the performance of school food authorities in operating the programs. Each year the state agency prepares a state plan for child nutrition operations as a condition for the receipt of federal funds. The state plan provides information about program participation, outreach needs, and proposed use of program funds, as well as plans for supervisory assistance and meeting other program requirements.

The state agency also is responsible for providing supervisory, technical and managerial assistance to school food authorities. State personnel are required to work with SFAs and provide supervisory assistance as needed. The state agency visits participating schools to ensure compliance with nutritional and record-keeping requirements. It establishes a financial management system through which the state conducts financial reviews and audits, and institutes a system of accounting and reporting for the SFAs.

The state agency is required to set up a reimbursement system with appropriate controls and follow-up procedures so that reimbursements to SFAs do not exceed allowable program costs. It also provides for the recovery of over-payments to SFAs. The state reviews all contracts between SFAs and food service management companies, and conducts on-site reviews of 20 percent of these contracts each year as required. The state agency is also responsible for commodity-only schools (i.e., schools that accept commodities but do not receive any other federal subsidy) and furnishes information to all SFAs about foods in plentiful supply and available donated commodities. The state agency sets up advisory councils to coordinate the distribution of commodities to local school districts.

In addition, the state agency is responsible for monitoring the performance of the school food authority. The state plan must include a monitoring plan that indicates how program performance at the SFA level is to be monitored, and how progress in reaching program goals and objectives is to be measured and evaluated. The state agency's monitoring of the school food authority is designed to exercise program control so that violations of regulations are recorded, tracked, and corrected. The scope of this monitoring includes, but is not restricted to, the review of violations occurring in the following areas: free and reduced-price policy, meal patterns, "offer vs. serve," and financial claims for reimbursement (i.e., claims are not to exceed allowable costs and are to be issued only to valid claimants).

The School Food Authority (District Level)

A school food authority (SFA) administers the program to ensure that it operates in conformance with federal regulations and guidelines such as meal pattern requlations and family size/income guidelines. In the public school domain, SFAs are usually at the district level, and they oversee programs in all participating schools in the district. In the private school domain, it is more common for each school to be an SFA, but sometimes groups of private schools will establish an SFA for the purpose of combining their food service functions.

The critical function of the SFA is to administer school nutrition programs at the school level. The SFA is responsible for assuring that the schools operate the programs according to the current purposes, regulations and guidelines established at the federal level.

In carrying out its functions of administering the food programs at the school level, the SFA has four major activities: food procurement and service, qualifying eligibles for free and reduced-price meals, financial recordkeeping, and monitoring school activities. It is generally the SFA that purchases food for school use and accepts foods donated by USDA. It maintains facilities for storing, preparing, transporting, and serving food, as necessary. It may enter into contracts with food service management companies to provide meals. The SFA also announces the free and reduced-price eligibility criteria to parents and releases the criteria to the local media. The SFA accepts applications and determines eligibility. It provides appeal procedures for settling disputes between parents and schools regarding eligibility determinations. The SFA keeps the eligibility applications on file so they are available for review by the state agency and regional office.

The SFA must keep accounting and fiscal records, which are made available to the state agency and the regional office for audit and review. It prepares an annual budget and ensures that the program operates on a non-profit basis. It submits claims to the state agency for reimbursement, based on the number of meals served. In addition, the SFA monitors the operation of the programs in the schools.

The School Level

Finally, the school prepares food according to the USDA meal pattern guidelines and serves meals to all children. It establishes procedures to prevent peer identification of children who participate free or at reduced price in the programs. It collects data on meals served and on student payments. It collects applications from parents for free and reduced-price participation in the programs and forwards them to the school food authority for eligibility determination.

C. *How Are the School Nutrition Programs Funded?*

The Food and Nutrition Service makes payments to the participating state agencies who, in turn, distribute the funds to school food authorities operating the nutrition programs in schools within their jurisdictions. The amount of money paid to state agencies depends upon the number of reimbursable meals or half-pints of milk served to students. Performance funding is the mechanism for calculating payments; that is, each meal or milk served earns a standard federal payment. Since the requirements for the lunch, breakfast, and milk programs differ, they will be discussed separately. In addition to federal funds for meal and milk costs, commodities are distributed to SFAs, and special funds for the purchase of equipment are available to states.

Finally, the federal government provides administrative funds for state agencies to operate the programs. Each of these funding mechanisms is outlined separately in the following discussion.

School Lunch and Breakfast Programs

Currently the standard federal payment, or reimbursement* rate, for meals is adjusted semi-annually. The amount of reimbursement per meal is also dependent on the price category of the meal served: free, reduced price, or full price. All lunches, regardless of price category, receive general assistance, or Section 4 funds. For the period July 1 to December 31, 1980, state agencies receive Section 4 assistance amounting to 18.5 cents per meal. However, lunches served free or at a reduced price to eligible students receive an additional payment from special assistance, or Section 11 funds. Free and reduced-price lunches receive 83.5 and 63.5 cents, respectively, from Section 11 funds. The payment differs because the charge to students for reduced-price meals is generally 20 cents.* In addition to the federal funds awarded to each state, the states are required to provide support to the program under specific matching requirements specified in Section 7 of the National School Lunch Act.

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*All reimbursement rates discussed here refer to the period July 1, 1980 through December 1980. All states except Alaska earn federal payments based on the same standard rate. Alaska's standard payment rate is set higher to account for the difference in the cost of producing a meal in that state.

A similar payment mechanism exists for the breakfast program. All breakfasts receive a basic reimbursement of 14.75 cents, and free and reduced-price breakfasts receive an additional 37.25 and 27.75 cents, respectively. While states earn payments based strictly on the number of meals served, SFAs receive funds on a per-meal basis where they receive the lesser of (1) the rate of reimbursement or (2) the cost of the meal.

Within the funding structure of the lunch and breakfast programs there are provisions for schools to receive more than the average reimbursement rate if certain conditions exist. The lunch program "maximum" rates or the breakfast program "severe need" rates govern the distribution of additional funds. In the lunch program, if a school food authority can justify the need for greater federal payments based on high costs, the meals served at the school or schools where this exists may receive up to 24.5 cents for all lunches and $1.17 and 97 cents for free and reduced-price lunches, respectively. In the case of the breakfast program, if a school is designated by the state agency as in severe need, its free and reduced-price breakfasts may receive up to 62.75 and 57.75 cents per meal, respectively.

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*It could be as low as 10 cents if the entire state chooses to adopt a uniform statewide reduced price charge. In that case, Section 11 payments for reduced-price lunches would increase by 10 cents, to 73.5 cents.

Special Milk Program

As in the lunch and breakfast programs, states earn federal payments in the milk program based on the number of half-pints of milk served in participating schools and institutions. Schools and institutions have the option of either operating a "pricing" program where an identifiable charge for milk is established, or a "nonpricing" program, where all children are served milk with no separately identifiable charge for milk. In nonpricing situations, each half-pint of milk is reimbursed at 8.5 cents. Pricing programs may receive either 8.5 cents for all half-pints served, or may provide free milk to children eligible for free meals and sell milk to all other children. In the latter instance, reimbursement for free milk is set at the average cost per half-pint, and reimbursement for milk sold to students is set at 8.5 cents. The federal reimbursement rate is adjusted annually; as of September 1, 1980, the rate of reimbursement has been reduced to 5 cents in schools that serve the lunch or breakfast program.

Commodities Distributed in the NSLP

For each lunch served, states receive a commodity entitlement. The initial entitlement is based on the number of meals served in the previous school year multiplied by the national average value of donated foods. This average value is adjusted annually based on the Producers' Price Index of Foods Used in Schools and Institutions, which is derived from the Wholesale Price Index.

Commodities are donated to states on the basis of their entitlement. By May 15 of each school year, the amounts of commodities actually donated to each state are weighed against the entitlement, and the balance due to the states, if any, is distributed as cash in lieu of commodities. That is, USDA must determine by May 15 if 100 percent of the total entitlement to states will be met in commodities and, subsequently, what must be paid out in cash. The law states that at least 75 percent of a state's entitlement must be available in donated foods.

State Administrative Expense and Food Service Equipment Assistance Programs

Unlike the other school nutrition programs, both the State Administrative Expense (SAE) and the Food Service Equipment Assistance (FSEA) programs are formula grant programs. Their funding levels are established in the FNS budget authorization.

SAE funds are awarded to state agencies only and are used for state-level operating expenses, including funds for training and materials. The basic SAE grant for school nutrition programs is determined as the largest amount of one of the following:

- one percent of the program funds awarded during the second preceding year under Sections 4 and 11 of the National School Lunch Act and Sections 3, 4, and 5 of the Child Nutrition Act,
- $100,000, the minimum award, or
- not less than the amount awarded in the fiscal year ending September 30, 1978.

In addition to the basic grant, FNS makes additional SAE funds available for special purposes. For example, in FY 1980 four million dollars in discretionary SAE funds were made available for the implementation of the Assessment, Improvement and Monitoring System (AIMS).

The Food Service Equipment Assistance Program (FSEA) assists schools in areas with poor economic conditions in the establishment, maintenance and expansion of school food programs. FSEA grants are made to states based on two formulas for unreserved and reserved funds. Unreserved funds constitute 60 percent of the national FSEA appropriation and are allocated to states using the following formula:

$$\frac{\text{Number of lunches served in the state}}{\text{Number of lunches served in all states}} = \text{State share}$$

Within states, unreserved funds are allocated on a priority basis to schools without food service programs, schools that do not serve both breakfast and lunch but will use FSEA funds to initiate either breakfast or lunch, and schools without facilites to prepare hot meals on-site. After funds are made available to schools that qualify for the priority uses, the remaining funds are made available to all other schools.

Reserved funds constitute the remaining 40 percent of appropriated funds, and they are distributed to each state agency according to the following formula:

$$\frac{\begin{array}{l}\text{Number of children in the state in schools}\\ \text{without food service and in schools moving}\\ \text{toward the service of the SBP}\end{array}}{\begin{array}{l}\text{Number of children in all states in schools}\\ \text{without food service and in schools moving}\\ \text{toward the initiation of the SBP}\end{array}} = \text{State share}$$

As the formula indicates, reserved funds are used to assist schools without food service programs and schools that do not serve breakfast but that will use FSEA funds to initiate a breakfast program. Reserved funds are reallocated among the states once during the fiscal year; at a later date, any remaining reserved funds are reallocated as unreserved funds.

For both reserved and unreserved funds the state can provide up to 75 percent of the equipment costs, and the SFA must provide the remainder of the costs. However, in cases where a school that will be the recipient of FSEA funds has also been designated as "especially needy" for equipment, the state can provide the entire cost of the equipment.

These funding formulas are used to prepare the federal operating budget for the school nutrition programs. Table I-3 illustrates both budget authorities and actual obligations for the school nutrition programs in fiscal years 1976 through 1979. The data were derived from program budget documents. The budget authorities represent the Congressional allocation and establish the level of funds available to each program. The obligated amounts indicate funds actually used under each program on a nationwide basis. In some cases, the obligations exceed the budget authority; this is usually because the budget authority figures do not include unspent carry-over funds from previous years that may be obligated by the programs in the current year.

The application of performance funding is the primary mechanism for the allocation of resources by FNS. Although there is some discretion at the state level concerning the distribution of FSEA funds, performance funding is also the major determinant in the reimbursement of SFAs by the states. The allocation of resources from the federal level to the states and from the states to the SFAs and schools is based primarily on the number of meals or half-pints of milk served.

D. *What Are the Reporting Requirements Between Agencies at Different Levels?*

This section addresses the reporting requirements for the school nutrition programs at the school, school food authority, state agency, regional and national levels. The information presented in this section was derived primarily from the National School Lunch Program Regulations, Part 210. At the school level, the concern basically is with data collection; at the school food authority and state agency levels, the focus is on consolidating and summarizing the data in formal reports; at the regional level, these reports are edited and reviewed; and at the national level, the reports are consolidated and assessed for program performance trends and policy implications.

Table I-3. Funds Available Under the Budget Authority to the School Nutrition Programs and Funds Obligated, Fiscal Years 1976, 1977, 1978 and 1979
(dollars in thousands)

	FISCAL 1976		FISCAL 1977		FISCAL 1978		FISCAL 1979	
Program	Budget Authority*	Obligations	Budget Authority*	Obligations	Budget Authority*	Obligations	Budget Authority*	Obligation
Lunch	1,488,000	1,471,000	1,724,577	1,634,081	1,680,501	1,823,993	1,839,633	2,002,000
Breakfast	116,500	113,000	169,077	141,767	201,000	184,269	222,000	216,435
Milk	143,111	143,111	158,111	158,111	155,000	155,000	142,000	142,000
Commodities**	434,088	433,382	586,307	568,540	578,007	624,451	630,000	629,820
State Administrative Expense	11,150	8,860	13,675	13,035	13,675	19,200	31,077	29,070
Food Service Equipment Assistance	28,000	28,023	28,000	28,000	28,000	28,000	24,000	24,000
Total	2,220,849	2,197,376	2,679,747	2,543,534	2,656,183	2,834,913	2,888,710	3,043,325

*The budget authority figures exclude any carry-over funds available from the prior year unobligated balances; this accounts for why some actual obligations appear to be larger than authorizations.

**This includes the value of donated commodities and cash in lieu of commodities. It also includes commodities for the Summer Food Service Program, the Child Care Food Program, and the School Breakfast and Lunch Programs; however, the lunch program receives most of the total funds.

At the school level, meals are served to children on a free, reduced-price or full-price basis. Food managers, teachers, or other designated agents perform daily counts of meals served and of student meal payments and determine all costs of meal production including food, labor, and other costs. These data are then transmitted to SFAs.

At the SFA level, data collected from schools are used to prepare reimbursement claims and other reports, which are submitted to the state agency or to the regional office where applicable. In support of the claim for reimbursement, the SFA reports the number of meals served, cost data such as food costs, and income data such as the children's payments for meals. Additionally, in October and March the SFAs report the number of students eligible and the number approved for free and reduced-price meals, the number of schools operating the programs, school enrollment, and averge daily attendance. In response to its claim for reimbursement, the SFA receives monthly reimbursement from the state agency. Separate reimbursement claims may be submitted for each school participating in the programs, or the state agency may authorize the use of a Consolidated Claim for Reimbursement whereby the SFA submits a monthly claim for a group of schools. The private schools that are directly administered by the regional office report cost, income and participation data directly to the regional office on a monthly basis.

Using reports that are received from the SFAs*, the state agency organizes and summarizes data on standard reporting forms and submits monthly reports to the regional office. The monthly report (FNS 10) indicates the number of meals served, and the number of children in the state who received free meals, reduced-price meals, or full-price meals in the preceding months. Based on the data reported in FNS 10 by SFAs in October and March, the state agency reports the number of participating schools and enrollment data (FNS 47). The state agency reports quarterly to the regional office on expenditures for the various school nutrition programs (SF 269) and, on an annual basis, it reports revenues and costs for the different programs (FNS 13) and the food service status of all schools in the state (FNS 47). Based on claims for reimbursements submitted by the various school food authorities, the state agency draws on its Letter of Credit with the U.S. Treasury and makes reimbursement payments to SFAs.

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*Copies of all reports mentioned here are provided at the end of the chapter.

The state agency proposes and implements, subject to the approval of the regional office, various plans concerning the school nutrition programs. Each year, a state plan for child nutrition operations is prepared that details activities to improve and extend program operations. The state agency also submits to the regional office an annual plan for the use of State Administrative Expense funds, including a staff formula for state personnel. The state coordinator for the Nutrition Education and Training Program (NETP) prepares a comprehensive state plan for education which must be approved annually by the regional office.

In most cases the regional office receives, reviews and edits the various reports prepared by the state agencies within its jurisdiction. The edited reports are then submitted to FNS Washington for review. The regional office reviews the claims for reimbursement received from the private schools that are under its administration, certifies these claims to FNS Washington, which, in turn, authorizes the U.S. Treasury to make payments directly to those private schools. The regional office conducts a Management Evaluation (described in the following section) and prepares an annual report on the state agencies and SFAs under its jurisdiction. The report summarizes problems in the operation and financial management of the programs.

FNS in Washington reviews the reports from the regional offices and prepares national and regional summaries. These data are analyzed for trends and are subsequently used for program management. Upon receipt and approval of the state plans and upon the execution of a federal-state agreement for a school year, the U.S. Treasury is notified to issue Letter of Credit authorizations to make funds available to the states.

E. *What Monitoring and Evaluation Activities Occur?*

There are currently five monitoring and evaluation functions for the school nutrition programs. These are the Management Evaluations; audits; supervisory assistance; the Assessment, Improvement, and Monitoring System (AIMS); and research and evaluation on the operations and impacts of the programs.

The Management Evaluations (MEs) are conducted by the regional offices annually and assess the performance of the state agencies in administering the school nutrition programs at the school food authority and school levels. MEs measure the extent to which the program objectives outlined in the state plans are attained and provide an assessment of the effectiveness of state agency program administration. The regional offices conduct MEs by examining operations of the school nutrition programs at the SFA and school levels and by reviewing guidance documents prepared by the state agency such as supervisory assistance, etc. Guidelines for the MEs are drawn up at the federal level annually. In recent years, particular issues for assessment have been identified in addition to the broader purpose of comparing activities to stated objectives. These specific issues have included the following:

- Free and reduced-price meal policy, including reviews of applications, meal counts and reimbursements.
- Nutrition policy, primarily addressing the meal components.

- Reimbursement, assuring that reimbursement is limited to allowable costs.

More specific performance standards are defined from these issues by the federal office. The performance standards may also be revised annually.

The regional office uses the prescribed performance standards to guide the assessment of the state agencies. To monitor the state's management performance, the regional office visits selected SFAs. At the SFA level, the appropriate records and information related to the Management Evaluation guidance are reviewed. The regional office may also assess performance in areas other than those outlined in the ME guidelines that may be of concern in a particular state. The findings of the regional office are submitted to the state agency for review and comment, and a summary of the findings for each state is submitted by the regional offices to the School Programs Division of FNS.

At the federal level, the state summaries are reviewed and a national summary of Management Evaluation findings is prepared. The national summary lists the major problem areas that were identified by the MEs, and provides information for identifying weaknesses in the program. The national summary for 1979 cites the following problems:

- Reimbursement Rates--Clarification of state guidance to school food authorities, reconciliation of funds, implementation of cost-based accounting, and revision of forms. Some states had problems with procedures to ensure that reimbursement did not exceed the cost of the meal.

- A-102 Audit Requirement--Inability to achieve two-year audit cycle by end of FY 1979. Included here are states with problems in audit resolution, but more states had problems with the biennial audit requirement than with audit resolutions.
- Supervisory Assistance--Supervisory reviews that do not cover or inadequately cover major problem areas; absence of documentation; inadequate follow-up on deficiencies found.
- Free and Reduced-Price Policy--Inadequate state guidance, high error rates in approval of SFA policy statements, possible overt identification of students, and withholding of meals from children losing tickets.
- Meal Patterns--Deficiencies in the number of meal components and in food quantities.
- School Breakfast Program Expansion--Insufficient efforts or results in achieving expansion.
- Food Service Equipment Assistance--Improper approval process or authorization of funds.
- Operating Balance--Excessive operating balances or difficulties in determining balances.
- Rate assignment--Failure to assign and vary rates based upon meal cost.

The national summary includes a further discussion of the problems within each region. The regional offices are required to take corrective action on the basis of the ME findings.

The second major monitoring activity currently operating is the system of audits. There are two audit requirements which the programs must meet: (1) in general, one-third of the state agencies, all regional offices, and a sample of school food authorities are audited annually by the Office of the Inspector General, USDA; and (2) as a result of an OMB directive (A-102), all grantee agencies, in this case SFAs, must be audited once every two years. These biennial audits may be conducted by state or by outside auditors. The purpose of both types of audits is to review the financial records of the agencies administering the school nutrition programs in order to verify the fiscal management of the programs.

Findings from state and regional audits conducted by the Office of the Inspector General are reviewed by FNS. Audits of school food authorities are reviewed by the regional offices unless extensive fiscal problems are identified, in which case the findings are also reviewed by FNS in Washington.

Audit findings are also compiled in a national summary, which is released together with the ME findings. The major fiscal problems identified for FY 1979 were the following:

- Reimbursement rates exceeded per-meal cost.
- Indirect costs were improperly handled.
- Cost-based accounting was not implemented or was improperly implemented.
- Inaccurate fiscal reports were submitted to state agencies.
- Equipment depreciation was improperly handled.
- Free and reduced-price meals were provided to ineligible children.
- Meal counts were inaccurate.
- Meal patterns were not met.
- Adult meals were included for reimbursement.
- Free and reduced-price recipients were permitted to be overtly identified.

Some of the findings overlap with those of the Management Evaluations. The federal and regional offices share the responsibility for coordinating the correction of fiscal problems.

Supervisory assistance, which is the third monitoring and evaluation function, is provided by state agencies to SFAs and schools as needed. A plan for supervisory assistance must be outlined in the state plan each year and must include the following components: (1) objectives of the assistance, (2) reasons for the selection of those objectives, (3) activities to accomplish the objectives, and (4) evaluation to assure the objectives are being met. The purpose of this plan for supervisory assistance is to establish a method for states to monitor program performance and provide assistance when appropriate. The supervisory assistance carried out under the plan includes visits to SFAs and schools to assist in compliance with the various federal program regulations. In recent years, certain regulatory requirements have been identified at the federal level as areas in need of additional monitoring. Such areas include fiscal accountability to assure that reimbursements do not exceed allowable costs; free and reduced-price policy to verify that the number of free and reduced-price meals served do not exceed the number of free and reduced-price eligibles; meal pattern requirements to determine that the appropriate meal components are served; and nondiscrimination regulations to ensure that Civil Rights requirements are met. Supervisory assistance findings are prepared by the state agencies and are reviewed by regional offices during the annual Management Evaluation.

As a result of recent legislative and management concerns, AIMS has been implemented by FNS to supplement other monitoring activities. AIMS, the fourth monitoring and evaluation activity described here, structures the state's review of SFA and school performance activities that are outside the scope of the supervisory assistance. Such monitoring was formerly done at the discretion of the state agency. The objectives of AIMS are "to analyze current school lunch and breakfast program management by states; to monitor effectively the use of federal funds; and to protect the nutritional integrity of meals served under the programs" (AIMS, Proposed Regulations, October 1979).

AIMS refocuses the intent of program monitoring by providing a clearly specified set of criteria for states to use in monitoring operations and assessing discrepancies associated with program reporting and reimbursement; AIMS also includes a system of corrective action and sanctions to effect improvements. The AIMS guidelines define five performance standards for SFAs and schools as follows:

- All applications for free and reduced-price meals must be correctly approved or denied.
- The numbers of free and reduced-price meals claimed for reimbursement in each school must be less than or equal to the number of children in that school correctly and currently approved for free and reduced-price meals, respectively, times the days of operation for the reporting period.
- The system for counting and recording meal totals for paid, free and reduced-price meals claimed for reimbursement at both school food authority and school levels must yield correct claims.
- Meals claimed for reimbursement must contain food components as required by regulations.
- Reimbursement claimed for meals must be limited to allowable costs as documented by reviewable records.

In addition to the systems described above, FNS through its Office of Policy, Planning, and Evaluation (OPPE) assesses the efficiency and effectiveness of FNS programs, demonstrations, and pilot projects. OPPE also provides leadership and technical assistance throughout FNS in the area of program evaluation. The office responds to inquiries about evaluations from agencies outside of USDA such as the General Accounting Office and the Office of Management and Budget.

F. *What Functions Related to Food Procurement Occur at the Various Levels?*

The lunch, breakfast, and milk programs have a complex food procurement system that operates in a variety of ways. The system begins with the acquisition of food, usually includes the processing, storage, and transportation of food, and ends with the preparation and delivery of food to children. Many of these major functions in the food system may occur at different program levels (national, regional office, state, school food authority (district), or school), and several of the functions can be performed in different ways; for example, food can be acquired either through donated commodities or through direct purchase. It appears that the functions of the national and regional offices are fairly standard with regard to commodities, however, at the state level and below, there are diverse functions which are not tied to any one level. This section summarizes the roles of agencies at the various program levels in the food procurement system.*

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*Unless otherwise indicated, all information in this section is based on interviews with school programs staff and with staff of the Food Distribution Division.

The federal level is directly responsible for the purchase of food, which is subsequently distributed to states, SFAs, and schools as donated commodities. Donated commodities represent 20 percent of all food used by schools, whereas the remaining 80 percent of the food is purchased, usually by SFAs, using federal per-meal reimbursements, children's payments, and other revenues available to the programs. USDA has been authorized to purchase foods for distribution to schools under five separate legislative authorities: Section 32 of the Agricultural Adjustment Act of 1935, Section 416 of the Agricultural Act of 1949, Sections 6 and 14 of the National School Lunch Act of 1946, and Section 709 of the Food and Agriculture Act of 1965.

The Commodity Credit Corporation was established in 1933 to provide price supports for farmers. When the price supports led to an accumulation of food stock, commodity distribution programs were initiated in 1935 to continue the system of price supports and to provide food assistance by distributing excess commodities. Section 32 of the Agricultural Adjustment Act of 1935 provided the first enabling legislation. Under Section 32, USDA is authorized to purchase temporary market surpluses of perishable products in order to stabilize farm prices. Surplus has been defined as either physical (supplies exceeding requirements) or economic (prices below desired levels). Section 32 foods generally include fruits, beef, pork, vegetables, canned and frozen poultry, eggs, dry beans and peas. Section 32 is funded by a continuing appropriation of 30 percent of the custom's receipts collected on all goods, non-agricultural as well as agricultural, that are imported into the country.

Section 416 of the Agricultural Act of 1949 authorized USDA to distribute commodities predetermined by Congress and USDA to be eligible for price support and to be surplus, and then only when such disposition is necessary to prevent waste. The commodities are usually basic items such as wheat, corn, rice, barley, oats, peanuts and dairy products. Section 709 authorizes

USDA to use funds of the Commodity Credit Corporation to purchase at market prices, sufficient supplies of dairy products (other than fluid milk) for any school nutrition program.

The National School Lunch Act of 1946 authorized USDA to provide a broad range of commodities to the school nutrition programs under Section 6. These commodities are not limited to price support or surplus restrictions, and it has been department policy to use Section 6 funds to purchase commodities which the states report as being preferred. Special emphasis is given, under Section 6, to the purchase of high-protein foods such as meat and meat alternatives. Section 14 of the school lunch legislation authorizes the expenditure of funds from Sections 32 and 416 to purchase commodities customarily bought and donated under those sections but which currently do not meet the surplus requirements of those sections.

The Food Distribution Division (FDD) of FNS is the federal office that coordinates the allocation of commodities. FDD determines, within legislative constraints and with assistance from the states, which foods will be purchased and the quantities that are necessary. The quantity of food purchased is based on the value of total state entitlements. Each state receives an amount of commodities, or entitlement, valued at a specified cash amount per meal served under the school food programs. FDD determines the allocation of the donated commodities. The purchases of such commodities, however, are made by other agencies. The Food Safety and Quality Service (FSQS) arranges for the purchase of all foods under Sections 6, 14, and 32. The Agricultural Stabilization and Conservation Services (ASCS) has responsibility for purchasing Section 416 and bonus foods and for distributing all foods.

These federal agencies arrange for purchases of food, either in raw or processed form, and pay for the transportation of the commodities to the states. There is no federally supported storage of food. The federal government assumes the purchase price and the transportation costs to designated warehouses. At this point, the states assume responsibility for the commodities. Between the time that plans for commodity purchases are made at the federal level and the delivery of food to states is completed, the FNS regional offices determine the exact distribution of food among states.

The states are responsible for the actual distribution of food to SFAs. This is generally done by the State Education Agency and/or the State Distribution Agency. Once commodities are received by the states, several options are available; states can store and/or process and/or transport the commodities. Donated commodities may be stored at state warehouses until picked up by the SFAs, or states may arrange to process some of the donated commodities. Processing is usually done to increase the acceptability of certain commodities to the SFAs. For example, non-fat dry milk may be processed into mozzarella cheese, which is easier for schools to use, or it may be combined with other commodities into consumable products such as pizza. Processing is done under contract, and states may charge the SFAs for processing or may assume the costs themselves. Processed commodities may be returned to state warehouses for storage until picked up by the SFAs, or deliveries may be made directly to the SFAs. The storage and transportation of commodities can take many forms. In general, once commodities are turned over to the states, some form of processing, storage, and/or transportation occurs. States must receive at least 75 percent of their commodity entitlement in food, and the balance may be given in cash for additional food purchases, which are usually made at the SFA level.

Kansas is the only exception to this process at the state level. In 1973, when the state was faced with significant changes in its food distribution facilities involved in Food Stamps, Kansas chose to disband its commodity distribution program entirely. A legislative mandate issued in PL 94-105 authorized USDA to allow Kansas to continue participating in the school commodities program by disbursing all cash-in-lieu of its commodity entitlement beginning in November 1974. The cash received by the state is distributed to the SFAs to purchase food.

The SFAs have some choice over which donated commodities they will accept from the state, and may refuse entitlement commodities they will not use. The states are not obligated to replace refused commodities. It is at the SFA level that most foods other than donated commodities are purchased in the open market.

In a study conducted for FNS, data concerning the volume of food purchased, prices, delivery arrangements, storage and transportation, quality control, local competition, and bid procedures were collected, and models of the existing systems were developed based on the food procurement practices of nine school systems (Kearney Management Consultants, 1978). The administrative model indicates that foods other than USDA-donated commodities are purchased either by the individual school, school district, or multidistrict consortiums. The latter is defined as two or more districts that consolidate their food purchasing either by using existing administrative staff or by establishing a separate legal entity with responsibility for food purchasing. The study also indicates that states may purchase some foods for school use. Depending on the size of the SFA, there may be storage and transportation systems at this level, and additional processing of foods and/or donated commodities may occur, which usually requires solicitation of bids and award of contracts. As with the purchasing functions, the storage, transportation, and processing responsibilities may be combined among districts.

The primary function of the school in the food procurement system is the preparation and/or delivery of food to students. In a study of food delivery systems, Jansen et al. (1977) described four such systems: (1) on-site preparation and service, (2) central preparation with hot bulk delivery, (3) central preparation with chilled preportioned delivery, and (4) frozen preportioned delivery. In addition to these systems, many variations exist in the preparation and delivery of food, including, of course, the delivery of food to students by private food contractors or food service management companies.

Finally, a small number of schools, approximately 340 in 1978, did not participate in the National School Lunch Program but received donated commodities. Such schools receive donated foods under Sections 32 and 416.

G. *What Outreach Functions Are Performed?*

During the 1960s and 1970s, Congress indicated its intent for program expansion through legislative mandates. In order to carry out such mandates, FNS initiated program outreach activities to expand the school nutrition programs in terms of both numbers of schools and numbers of children participating. In recent years, special emphasis has been given to reaching needy children with the benefits of the program. FNS at both the national and regional levels engages in a number of public information activities such as the development and dissemination of program outreach materials. In addition, FNS provides assistance to the state agencies in state-level outreach activities, initiates special outreach efforts in conjunction with the state agencies, and monitors state outreach activities.

Each state agency details its expansion needs and objectives in an annual state plan. The state plan provides criteria for schools needing the programs, criteria for schools to be designated "in severe need," the number of schools targeted for program expansion, and specific outreach plans. In particular, the special efforts that are to be made to expand the school breakfast programs are indicated. The state agencies are required to mail breakfast program materials to food service managers in nonparticipating schools twice a year; they must mail general program materials and financial information to administrators in nonparticipating schools once a year; and they must visit schools targeted for expansion in the same year that they are being targeted.

At the local level, the SFA attempts to encourage eligible children to participate in the programs. The SFA provides parents with information regarding the eligibility criteria for receiving free or reduced-price meals, and releases this information to the news media, unemployment offices, and major employers that may be contemplating layoffs. The SFAs undertake to ensure that the eligibility application form is clear and easy to complete, and that free and reduced-price participants in the program are not overtly identifiable. The SFAs also arrange for fair hearing procedures for families who feel that their applications for free or reduced-price benefits have been improperly denied.

H. *Do the Programs Operate Differently in Private Schools Than They Do in Public Schools?*

The school nutrition programs that operate in private schools are administered in one of two ways: (1) they are administered by the state agency in exactly the same manner as the public schools, or (2) in states where state law prohibits the state agency from involvement in private schools, the programs are administered directly by the appropriate regional office. In the first case, there is no difference between the programs in public and private schools in terms of reporting requirements, flow of federal funds, monitoring, food service or other aspects of program operations. In the case of regionally administered programs, the private schools report directly to the FNS regional office. The regional office, in turn, prepares a state plan for these programs. Program operations in these private schools are similar to those in schools with programs administered by the state. The only difference is that private schools administered by the regions complete a special reporting form (FNS 806) which lists data similar to that reported on the FNS 10. The FNS 806 is completed by the school food authority on a monthly basis and is sent to the regional office. The only contacts the regional-office-administered programs (ROAPs) have with a state agency are those involving donated commodities; donated commodities are distributed to these private schools, like their public counterparts, by a state agency.

I. *How Many Students and Schools Participate in the Programs?*

Participation in the school nutrition programs is usually reported by FNS in two ways: (1) the number of schools operating programs, and (2) the number of meals consumed by participating students. The first of these figures measures the availability of the school nutrition programs, while the second figure measures the extent to which the programs are utilized. The data source for these two participation figures is the FNS 10 reporting form. The FNS 10 is completed by state agencies using data from the reimbursement claims submitted monthly by school food authorities. State agencies submit the FNS 10 to the FNS regional offices on a monthly basis. In those states that prohibit state involvement with private school operations, the private schools submit reimbursement claims on the FNS 806 directly to the FNS regional offices. All data are subsequently transmitted to FNS in Washington, where monthly and annual figures are consolidated, monitored and analyzed. The federal program staff prepares annual reports of program participation, as well as special reports and studies.

While the number of schools operating programs is the most commonly reported measure of the availability of school nutrition programs, there are several problems with this measure. Schools that operate programs are typically larger than those that do not. Many schools that do not operate programs are vocational-technical schools or work-study centers. Students often attend these schools for only a portion of the school day, the remainder of the day being spent at another school or at work. At some schools without programs, students participate in the nutrition programs operated by nearby schools. All of these facts tend to produce an underestimate of the actual availability of the school nutrition programs. The extent of the bias due to split school sessions and participation in services offered by other schools is difficult to determine. However, adjustments for differences in school size can be made. Table I-4 shows the percentage of total school enrollment in schools operating school lunch programs. One major difficulty in constructing such a table is the fact that school enrollment is defined differently by different sources. While the school enrollment figures used in Table I-4 are consistent with those reported by FNS for enrollment in schools participating in the NSLP, the use of other enrollment data frequently leads to participation measures over 100 percent (e.g., Beebout & Kendall, 1978).

The degree of utilization of school nutrition programs is measured in three different ways: the average daily meals (or half-pints), the participation rate, and the estimated number of participants. The first measure represents the total number of breakfasts, lunches, or half-pints of milk that are served to students daily. The participation rate for each of the three programs is usually calculated by dividing the average daily meals (or half-pints) by the average daily attendance. The estimated number of participants is obtained by applying the participation rate to the total enrollment, rather than to average daily attendance, thus yielding an estimate of the number of breakfasts, lunches, or half-pints of milk that would be served daily if no students were absent. If the frequency with which students participate in the school nutrition program is correlated with their attendance, then the estimated number of participants will be biased. If frequent participants are present more often than infrequent participants (i.e., attendance is positively correlated with the frequency of participation) then the estimated number of participants will be too high. If frequent participants tend to be absent more often than infrequent participants (i.e., attendance is negatively correlated with the frequency

Table I-4. Availability and Utilization of the National School Lunch Program, 1978-1979

State	Average Daily Lunches as Percent of Average Daily Attendance	Percent of Enrollment in NSLP Schools
Alabama	79.1*	90.5**
Alaska	45.6	74.9
Arizona	55.8	85.0
Arkansas	74.7	93.9
California	45.0	85.8
Colorado	56.7	87.6
Connecticut	54.4	71.1
District of Columbia	55.3	80.9
Delaware	62.4	77.7
Florida	67.9	87.7
Georgia	82.4	93.7
Hawaii	88.9	86.5
Idaho	56.8	97.4
Illinois	53.8	82.4
Indiana	63.3	97.0
Iowa	77.4	91.1
Kansas	73.1	90.2
Kentucky	78.8	92.0
Louisiana	84.7	88.8
Maine	63.7	88.0
Maryland	51.7	86.4
Massachusetts	65.6	88.4
Michigan	50.0	79.3
Minnesota	58.7	98.9
Mississippi	85.7	88.7
Missouri	68.8	91.4
Montana	58.9	89.9
Nebraska	72.2	63.0
Nevada	47.9	93.4
New Hampshire	58.5	90.6
New Jersey	46.9	83.9
New Mexico	63.3	97.2

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*Derived from preliminary FNS data for October 1978 for public and private schools.

**Derived from preliminary FNS data for October 1978 and Market Data Retrieval, Inc. enrollment data for public and private schools, 1978-1979.

Table I-4. Availability and Utilization of the National School Lunch Program, 1978-1979 (Cont'd)

State	Average Daily Lunches as Percent of Average Daily Attendance	Percent of Enrollment in NSLP Schools
New York	48.6	90.3
North Carolina	79.8	95.5
North Dakota	71.6	96.0
Ohio	51.9	93.7
Oklahoma	63.8	98.5
Oregon	59.6	86.7
Pennsylvania	45.6	100.0
Rhode Island	46.5	87.3
South Carolina	76.8	86.5
South Dakota*	68.1	93.8
Tennessee	73.4	88.2
Texas	63.7	89.2
Utah	69.2	97.4
Vermont	70.5	74.5
Virginia	68.4	90.1
Washington	45.3	94.3
West Virginia	93.6	83.2
Wisconsin	58.3	85.3
Wyoming	55.5	96.2

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*Preliminary October 1978 data for South Dakota appear to be in error. Rates are based on November 1978 through May 1979 average data for South Dakota.

of participation) then the estimated number of participants will be too low. Since not all students who participate in the school nutrition programs do so every day, the estimated number of participants will be considerably less than the number of students who participate in the programs at one time or another. For example, if students who participate in the programs typically do so only half of the time, then all three measures of participation would understate the number of students participating by half, since all three measures reflect average daily participation. Since students who receive free or reduced-price meals tend to participate with greater frequency than those who pay full price, the discrepancy will be greater in those situations in which there is a smaller proportion of meals served free or at reduced prices.

In addition to the regular annual reports and reports of a special nature prepared from the FNS 10 data, several special studies and surveys that have required primary data collection have been conducted by FNS in order to analyze participation rates. Two recent examples of such participation surveys are the 1972 National School Lunch Program Survey (USDA, FNS, 1974) and the Special Milk Program Evaluation and National School Lunch Program Survey (Robinson, 1975). In 1972, at the request of Congress, FNS conducted a survey of 650 schools representing the nation. The purpose of the survey was to determine the extent to which students participated in the lunch program. All data were collected in March 1972. Survey findings indicate that of 106,381 schools in the country, 79,588 or about 75 percent were participating in the National School Lunch Program at the time of the survey. Total school enrollment was 51.6 million students, of which 43.8 million were enrolled in schools with lunch programs. On the day of the survey, more than 24 million students, or 55 percent of the students enrolled in schools with lunch programs, received a Type A lunch. Further information on participation by racial groups and by types of food service facilities in operation was also reported. All data were drawn from operations on the single day of the survey (USDA, FNS, 1972).

In a later survey, conducted by FNS in 1975, 768 schools were studied to determine the levels of milk consumption as well as the extent of participation in the lunch program (Robinson, 1975). The findings of that study indicate that about 88 percent of the public schools in the country operated lunch programs and served an average of 24.5 million lunches each day. Robinson also reported that the breakfast program was available in about 11 percent of the schools in the the country and served an average of 1.5 million students a day, while the milk program operated in 82,000 schools nationwide, serving about 11.5 million half-pints to 9.2 million students each day.

USDA has also prepared several reports analyzing trends in participation. A review of all USDA-funded child nutrition programs that was prepared for Congress (USDA, 1974) discussed the social, educational, and demographic trends that have influenced program participation. The decline in birth rates during the 1960s resulted in declining school enrollment during the late 1970s. Changes in school operating characteristics, such as open-campus policies, work-study programs, and double sessions, also tended to reduce the participation rate by reducing the number of students who were on campus during breakfast and lunch hours. Changes in American eating habits also tended to lower participation rates. Several other factors, however, combined to offset these negative influences, resulting in a general increase in participation during recent years. The declining number of small neighborhood schools, the increase in sprawling residential developments, and the dramatic increase in the number of families with both parents employed, have all reduced the feasibility of students eating at home, thus increasing participation in school nutrition programs.

The Child Nutrition Review, another special report prepared by USDA for Congress, analyzed participation trends between fiscal 1969 and 1976. The results of this study are summarized in Table I-5. With the exception of a small decrease in 1974, the number of NSLP lunches received by students has

Table 1-5. Participation Trends in the Lunch Program, 1969-1976

Fiscal Year	Total School Enrollment (Millions)	Average Daily Number of Lunch Participants (Millions)				Percent of Enrollment Receiving Lunch Daily	Number of Meals Served (Millions)		
		Free	Reduced-Price	Full Price	Total		Free And Reduced-Price	Full Price	Total
1969	51.7	2.9	*	16.5	19.4	37.5	508	2,860	3,368
1970	52.1	4.6	*	17.8	22.4	43.0	739	2,826	3,565
1971	52.0	6.3	*	17.8	24.1	46.3	1,006	2,842	3,848
1972	52.0	7.9	*	16.6	24.5	47.1	1,285	2,687	3,972
1973	51.4	8.4	.2	16.1	24.7	48.0	1,402	2,607	4,009
1974	51.4	8.8	.3	15.5	24.6	47.9	1,478	2,504	3,982
1975	51.1	9.4	.6	14.9	24.9	48.7	1,638	2,425	4,063
1976	50.5	10.0	.8	14.7	25.5	50.5	1,767	2,403	4,170

*Free and reduced-price figures were reported together until 1973.

increased steadily since 1969 in spite of declining school enrollment. This increase between 1969 and 1976 has been due to the dramatic growth in the number of free and reduced-price lunches served, the number of full-price lunches having decreased slightly during the period. By 1976, approximately half of all students received an NSLP lunch on a typical school day.

Participation data are collected on a regular basis by FNS from the FNS 10. For the three years since the Child Nutrition Review was released, these data have been collected by FNS and are summarized in Tables I-6 through I-8 for the three school nutrition programs. These data are only preliminary, since corrections and revisions are routinely received and incorporated for up to five years after the original FNS 10 forms are due. Therefore, the data are likely to be more accurate for earlier years than for the most recent years.

Table I-6 shows a slight increase in the number of schools operating programs, but a small decrease in enrollment and attendance. In spite of the decline in enrollment, the number of lunches served has increased steadily. Unlike the period before 1976, this increase has been due primarily to the larger number of full-price meals served, since there were only small increases in the number of reduced-price meals and decreases in the number of free meals. Since the number and enrollment of schools operating programs have not increased significantly, this growth is largely attributable to the increased participation rate of students in schools that operate school lunch programs.

Table I-7 shows quite different trends for the School Breakfast Program. Starting with a significantly smaller number of schools operating the program than the NSLP, the breakfast program has increased in the number of schools participating and the enrollment in these schools. Increases have occurred in the number of breakfasts served in all three price categories, but the participation rate has remained relatively constant.

Table I-6. Participation in the School Lunch Program, 1977-1979

	School Year		
School Lunch Program	1976-1977 (millions)	1977-1978 (millions)	1978-1979 (millions)
October			
Schools Operating Program*	89,052	90,196	90,800
Enrollment in Schools With Program	44.8	44.9	44.6
Average Daily Attendance	41.4	41.4	40.9
Average Daily Lunches	24.3	24.5	24.6
Estimated Number of Participants			
Free	10.6	10.3	9.9
Reduced-Price	1.3	1.6	1.7
Full-Price	14.6	14.8	15.1
Total	26.5	26.6	26.8
March			
Schools Operating Programs*	88,828	90,054	91,201
Enrollment in Schools with Program	44.6	44.7	43.9
Average Daily Attendance	40.9	41.0	39.9
Average Daily Lunches	23.8	24.3	24.6
Estimated Number of Participants			
Free	10.6	10.4	10.0
Reduced-Price	1.3	1.6	1.7
Full-Price	14.3	14.8	15.4
Total	26.2	26.7	27.1
Annual Number of Lunches Served			
Free	1,690	1,617	1,601
Reduced-Price	211	247	273
Full-Price	2,354	2,378	2,480
Total	4,254	4,242	4,353

*Actual number

Table I-7. Participation in the School Breakfast Program, 1977-1979

School Breakfast Program	School Year		
	1976-1977 (millions)	1977-1978 (millions)	1978-1979 (millions)
October			
Schools Operating Programs*	18,341	20,996	26,672
Enrollment in Schools With Program	9.2	10.8	13.3
Average Daily Attendance	8.6	9.9	12.4
Average Daily Breakfasts	2.1	2.4	2.9
Estimated Number of Participants			
Free	1.9	2.1	2.4
Reduced-Price	.1	.1	.2
Full-Price	.3	.4	.5
Total	2.3	2.6	3.1
March			
Schools Operating Programs*	19,437	21,660	27,655
Enrollment in Schools With Program	9.7	11.3	14.2
Average Daily Attendance	8.7	10.2	13.0
Average Daily Breakfasts	2.2	2.5	2.9
Estimated Number of Participants			
Free	2.1	2.2	2.5
Reduced-Price	.1	.1	.2
Full-Price	.3	.4	.5
Total	2.5	2.7	3.2
Annual Number of Breakfasts Served			
Free	325	341	387
Reduced-Price	18	25	33
Full-Price	56	66	85
Total	399	432	506

*Actual number

Table I-8 shows the Special Milk Program experiencing a decrease in total number of half-pints of milk served, with sporadic variation in the number of institutions participating.

DISCUSSION

In 1935, federal legislation authorized the Secretary of Agriculture to donate surplus food commodities to elementary and secondary schools. The legislation was intended to remove surplus food commodities from the market and support farm incomes, while providing lunches to school children. The 1946 National School Lunch Act permanently authorized the school lunch program with appropriations "as may be necessary." Its primary objective was to safeguard the health of school children by providing nutritious meals, and the use of surplus food commodities became a secondary objective. It also required local school authorities to serve free or reduced-price meals to children unable to pay the full price. The program operated for the next 20 years with only minor modifications.

With the Child Nutrition Act of 1966, the existing lunch program was strengthened. The Special Milk Program (which had been initiated in 1954 as part of the lunch program) was made a specific program with funding through 1970, and a pilot program known as the School Breakfast Program was created with funding through 1968. Throughout the seventies, legislation extended and expanded the school nutrition programs, with special emphasis on poor and needy children. The Special Milk Program was made permanent in 1970, and the School Breakfast Program was made permanent in 1975. Other legislation was intended to increase the frequency of reimbursement for schools and to improve the quality of the meals served. However, recent legislation has emphasized fiscal austerity and program accountability.

Since the programs began, federal legislation has created a complex system for managing the programs. While there are a variety of offices within USDA

Table I-8. Participation in the Special Milk Program, 1977-1979

Special Milk Program*	School Year 1976-1977 (millions)	 1977-1978 (millions)	 1978-1979 (millions)
October			
Schools Operating Program**	84,120	84,948	84,537
Average Daily Half-Pints Served	12.6	12.2	10.7
Monthly Number of Half-Pints Served			
Free	52.8	51.9	29.1
Full-Price	200.6	193.0	195.0
Total	253.4	244.9	224.1
March			
Schools Operating Program**	84,577	85,595	85,324
Average Daily Half-Pints Served	11.7	10.3	10.2
Monthly Number of Half-Pints Served			
Free	58.6	27.1	27.6
Full-Price	197.5	172.5	183.2
Total	256.1	199.6	210.8
Annual Number of Half-Pints Served			
Free	469	327	229
Full-Price	1,714	1,621	1,597
Total	2,183	1,948	1,826

*Data are not disaggregated for schools and residential child care institutions; therefore, combined figures are reported here.

**Actual number

that have some responsibility for the programs, the principal administering agency is the Food and Nutrition Service (FNS). In general, federal policy is interpreted by the FNS regional offices, which then assist and supervise the state agencies in carrying out federal regulations and guidelines. In turn, the state agencies manage the programs within the states by providing assistance to local School Food Authorities (SFAs) as needed, and by monitoring SFA performance and establishing fiscal record-keeping systems. At the local level, SFAs administer the program in schools that they supervise, in accordance with all of the appropriate legislation, regulations, and guidelines. Finally, individual schools are responsible for preparing nutritious food and making it available to all children.

The school nutrition programs are supported primarily by a performance funding mechanism. The allocation of resources to the states by the federal government, and subsequently to the SFAs by the states, is based on reimbursement for each meal or half-pint of milk served. Since the school nutrition programs began, reimbursements to schools have steadily increased, due to increases in benefit levels, in the number of schools operating the programs, and in the number of meals consumed by students.

While this chapter describes the context and operations of the school nutrition programs, based on legislation, regulations and guidelines, it should be noted that we do not know the extent to which actual operations differ from the ideal or legislated description that was provided in this chapter. Empirical data are needed to give a complete picture of program operations. When such data are collected, the information presented in this chapter can be used for analyzing discrepancies between actual operations and legislative intent.

As discussed, the objectives of the school nutrition programs have changed over the years, from an initial emphasis on agricultural price supports to a later emphasis on child nutrition and health. As the programs have grown, a comprehensive organizational and operational structure has developed that involves the federal government, every state, and most school districts and schools. The programs provide services to a large proportion of the public and private school students throughout the country, and have a significant effect on the nation's economy.

FNS REPORTING FORMS

FNS 10

FORM APPROVED OMB NO. 40-1535

US DEPARTMENT OF AGRICULTURE FOOD AND NUTRITION SERVICE **REPORT OF CHILD NUTRITION OPERATIONS** FNS Instr. 794-3	1. PREPARED BY ☐ State Agency ☐ Regional Office	2. TYPE OF SUBMISSION ("X" one) A ☐ Initial B ☐ Revision No. _ (1=1st rev., 2=2nd, etc.) C ☐ Final	FOR FNS USE ONLY 3. STATE 4. MONTH AND YEAR

STATE AGENCY: Report should be mailed within 30 days following the period being reported. Prepare in *triplicate*. Send *original* to Regional Administrator, Food and Nutrition Service, *duplicate* to Director, Central Accounting Division, FNS, Washington; retain *triplicate*.

REGIONAL OFFICE: Retain *original*, mail *duplicate* to the Director, Central Accounting Division within 30 days following the period being reported.

REPORT PERIOD	ITEM *(Place an "X" in the space provided if all figures for an item are final.)*	Mark "X"	Paid (A)	Free (B)	Reduced Price (C)	Total (D)	Average Daily Meals (E)
			NUMBER OF MEALS AND HALF-PINTS SERVED				
MONTHLY	*(Include Residential Child Care Institutions (RCCIs) in Items 5 thru 8.*						
	5. NATIONAL SCHOOL LUNCH PROGRAM						
	6. SCHOOL BREAKFAST PROGRAM *(Include schools with severe need)*						
	7. SCHOOL BREAKFAST PROGRAM *(Severe need only)*						
	8. COMMODITY ONLY SCHOOLS *(Lunches only)* . .						
	9. SPECIAL MILK PROGRAM a. Schools *(Include Residential Child Care Institutions)* . .						
	b. Nonresidential Child Care Institutions						
	c. Summer Camps						
OCTOBER AND MARCH ONLY	10. REPORT NO. OF MEALS SERVED IN RCCI's ONLY. *(Include in Item 5 through 9a above)* a. National School Lunch Program						
	b. School Breakfast Program						
	c. Severe Need School Breakfast Program						

11. ESTIMATE THE TOTAL NUMBER OF CHILDREN WHO ARE ELIGIBLE FOR FREE AND REDUCED PRICE LUNCHES UNDER THE SCHOOLS' AND RESIDENTIAL CHILD CARE INSTITUTIONS' ELIGIBILITY STANDARDS FOR SUCH LUNCHES . . . .

		FREE	REDUCED PRICE
12. APPROVED FOR FREE AND REDUCED PRICE LUNCHES a. Number of children in schools and RCCI's. . . .			
b. Number of children in RCCI's.			

OPERATING A PROGRAM THIS MONTH		National School Lunch (F)	School Breakfast *(Incl. Sev. Nd.)* (G)	School Breakfast *(Severe Need Only)* (H)	Commodity Only (I)	Special Milk (J)
13.a. Number of Schools *(Exclude Residential Child Care Inst. in Cols. F thru I, but include them in Col. J)*						
b. Membership *(Enrollment)*						
c. Average Daily Attendance						
14.a. Number of Residential Child Care Institutions .						
b. Membership *(Enrollment)*						
15. Number of Nonresidential Child Care Institutions .						
JULY ONLY: 16. NUMBER OF SUMMER CAMPS OPERATING A PROGRAM FOR THE MONTH OF JULY ONLY .						

REPORT PERIOD	FOOD SERVICE EQUIPMENT ASSISTANCE PROGRAM (FSEA) *(Include Especially Needy)*		Unreserved FSEA Funds: Initiating NSLP Service (K)	Unreserved FSEA Funds: Initiating SBP Service (L)	Unreserved FSEA Funds: Maint. + Expansion (M)	Reserved FSEA Funds: Initiating NSLP Service (N)	Reserved FSEA Funds: Initiating SBP Service (O)
DECEMBER, MARCH, JUNE AND SEPTEMBER	17.a. No. Schools & RCCI's Approved for FSEA Funds this Quarter						
	b. Membership *(Enrollment)*						
	18.a. No. Schools & RCCI's Receiving FSEA Funds this Quarter						
	b. Membership *(Enrollment)*						
	ESPECIALLY NEEDY FSEA ONLY 19.a. No. Schools & RCCI's Approved for FSEA Funds this Quarter						
	b. Membership *(Enrollment)*						
	20.a. No. Schools & RCCI's Receiving FSEA Funds this Quarter						
	b. Membership *(Enrollment)*						

I CERTIFY that this report is true and correct to the best of my knowledge and belief	AGENCY	
SIGNATURE	TITLE	DATE SIGNED

FORM FNS-10 (7-79) *(Previous editions are obsolete.)*

No further monies or other benefits may be paid out under these programs unless this report is complete and filed as required by existing regulations (7 C.F.R. 210, 215, 220 & 230)

INSTRUCTIONS

(All items self-explanatory unless noted below)

For each applicable month, all schools, residential and nonresidential child care institutions, and summer camps known to have operated a program during the month being reported should be accounted for on this report. The initial report should include data from the claims actually received and ESTIMATES for those which have not been received by the reporting due date. In any event, any data reported which is not based solely on actual claim data should represent the best estimate of the reporting office of the actual level of operation. (See MONTHLY REPORTING for a more complete discussion of estimating procedures.)

For completion of Form FNS-10, the following reporting schedule should be followed:

1. Items 5 through 9, MONTHLY.
2. Items 10 through 15, TWICE A YEAR for October and March.
3. Item 16, ANNUALLY for July.
4. Items 17 through 20, QUARTERLY, for the quarters ending March 31, June 30, September 30, and December 31.

If any of the items do not apply to the State Agency's operation, please leave appropriate spaces blank. FNS Regional Offices should complete only Item 8 Columns A through E, Items 13 and 14 Column I, and Items 17 through 20, Columns K through O.

Definitions (For the purpose of this report):

1. "Average Daily Attendance" is the aggregate days attendance of a given school during a given reporting period divided by the number of days school is in session during this period. The average daily attendance for groups of schools having varying lengths of terms is the sum of the average daily attendances obtained for the individual schools.

2. "Average Daily Meals Served" is the total meals reported divided by the number of food service operating days during the month being reported. As an expedient, it may be determined in accordance with the following example: School A served for 20 days a total of 2,000 meals; 2,000 divided by 20 equals an average of 100 meals served daily. School B served for 16 days a total of 2,400 meals; 2,400 divided by 16 equals an average of 150 daily. One hundred (Average daily meals served for School A) plus 150 (Average daily meals served for School B) equals 250, total aggregate average daily meals for the two schools.

3. Membership (Enrollment) - A pupil is a member of a school from the date he presents himself at school and is placed on the current roll until he permanently leaves the school for one of the causes recognized as sufficient by the State. The date of permanent withdrawal should be the date on which it is officially known that the pupil has left school, and not necessarily the first day after the date of last attendance. Membership is obtained by adding the total original entries and the total reentries and subtracting the total withdrawals; it may also be obtained by adding the total number present and the total number absent. This term is also known as the number belonging. This same definition may be applied to residential child care institutions.

4. A "Nonresidential Child Care Institution" is a licensed nonschool public or nonprofit private institution providing day care services where children are not maintained in residence.

5. A "Residential Child Care Institution" is a public or licensed nonprofit organization including but not limited to orphanages, homes for the mentally retarded, etc., where children are maintained in residence.

6. A "School" is an educational unit of high school grade and under operating under public or nonprofit private ownership in a single building or complex of buildings. When separately administered elementary and secondary grade levels are housed in the same building, each is considered a separate school. When both levels are administered as one unit, it should be considered a single school.

7. A school with "Severe Need" is a school which is approved for School Breakfast Program reimbursement in excess of the specified standard rates of reimbursement. A school with severe need was known as an Especially Needy school prior to Public Law 95-166.

8. A "Paid Meal" is one which is served to a child who has not been determined to be eligible to receive "free or reduced price meals," as defined below.

9. A "Free Meal" is one which is served to a needy child determined to be eligible for such meal under the eligibility criteria of the School Food Authority or residential child care institution approved by the State Agency.

10. A "Reduced Price Meal" is one which is served to a needy child determined to be eligible for such meal under the eligibility criteria of the School Food Authority or residential child care institution approved by the State Agency. The reduced meal price must be less than the full meal price and must be 20 cents or less for lunches and 10 cents or less for breakfasts.

11. "Free Milk" is milk served under the Special Milk Program to needy children determined to be eligible for such milk under the eligibility criteria of the School Food Authority or child care institution approved by the State Agency.

12. "Total Meals" and "Total Half-pints of Milk" are all free, reduced price, and paid meals and all free and paid milk served during the month being reported to all eligible children participating in the child nutrition programs covered by this report.

13. The term "Initiating SBP Service" refers to any school approved to receive or currently receiving Food Service Equipment Assistance funds for initiating the School Breakfast Program.

14. The term "Initiating NSLP Service" refers to any school approved to receive or currently receiving Food Service Equipment Assistance funds for initiating the National School Lunch Program.

MONTHLY REPORTING

Note: If complete claim data is not available for Items 5 through 9 by the due date, estimates will need to be developed to complete the report. While the reporting office may use whatever methods are most suitable to their needs, the following methods are suggested:

(a) For FNS-10 reports which are based on partial estimates: For all claims not received for schools and institutions known to be operating a program(s), adjust the most recently received claim record available for each reporting unit to the days of operation for the current month. This sum of estimated outstanding claims when added to the tabulation of claims actually received should provide a reasonably accurate estimate for total program operations for the month being reported.

(b) For FNS-10 reports which are based totally on estimates: If it is not practical to consider any actual claims received when making estimates, use historical data—such as the previous month or the same month of the previous year—and adjust to the days of operation of the month being reported to make the estimate. Make reasonable adjustments for any known program growth or decline.

IT IS ABSOLUTELY ESSENTIAL TO SUBMIT REVISED FNS-10 REPORTS FOR ALL ESTIMATED REPORTS WHEN ACTUAL CLAIM DATA BECOMES AVAILABLE.

Item

2. If the initial submission is based on final claim data, check Items 2a and 2c.

5. Enter in appropriate columns the number of lunches served in schools and residential child care institutions to eligible participants. Any lunches served to persons not eligible for program participation or any served that do not meet the Type A pattern are examples of lunches that must not be reported.

Item

6. Enter in appropriate columns the number of breakfasts served in schools and residential child care institutions to eligible participants. Include breakfasts served in schools and residential child care centers designated by the State Agency as Severe Need programs. Any breakfasts served to persons not eligible for program participation, or any served that do not meet at least the basic meal requirements are examples of breakfasts that must not be reported.

7. Following the same procedure as for Item 6, report only free and reduced-price breakfasts served in the Severe Need programs. Those breakfasts should be included in Item 6. Report the total of free and reduced-price Severe Need breakfasts in Column D of Item 7.

8. Enter in appropriate columns the number of lunches served to eligible participants. Include lunches served in both Commodity-Only schools and Commodity-Only residential child care institutions. Any lunches served to persons not eligible for program participation, or any served that do not meet the requirements as set forth in §210.15a of the NSLP regulations, are examples of lunches that must not be reported.

Note: For items 5 through 8, Column E, compute "Average Daily Meals Served" in accordance with the above Definition No. 2.

9. Enter in appropriate columns by applicable outlet unit the number of half-pints of milk served in the Special Milk Program (SMP) to eligible participants. Milk served in nonpricing outlets should be counted as paid milk served. Include SMP milk served in residential child care institutions with milk served in schools.

TWICE-A-YEAR REPORTING AS OF OCTOBER 1 AND MARCH 1

10. Enter in appropriate columns the number of lunches and breakfasts served in residential child care institutions to eligible participants. Any meals served to persons not eligible for program participation, or any served that do not meet at least the basic meal requirements are examples of meals that must not be reported. For Item 10c, report the total of free and reduced-price Severe Need breakfasts in Column D.

11. Each school and residential child care institution participating in the National School Lunch Program is required by law to provide an estimate to the State Agency as of October 1 and March 1 each year of the number of children who are eligible for a free or reduced price lunch. The data must accordingly be compiled by the State Agencies and reported to FNS. Enter this data in Item 11.

12a. and 12b. Report the number of children who have current and complete applications on file, and who have been approved for 1) free lunches, and 2) reduced-price lunches.

13. Enter in appropriate columns the number of schools participating in the child nutrition programs covered by this report. For the Special Milk Program only, combine the number of participating residential child care institutions with the number of schools and report in Column J. Enter in the appropriate columns the aggregate membership (enrollment) of participating schools only and their aggregate average daily attendance.

Item

14. Enter in appropriate columns the number of residential child care institutions participating in the lunch, breakfast, and commodity only programs and their aggregate membership (enrollment).

15. Enter in Column J the number of nonresidential child care institutions participating in the Special Milk Program.

ANNUAL REPORTING

16. Enter in Column J the number of nonprofit summer camps participating in the Special Milk Program during the month of July.

QUARTERLY REPORTING

Notes: Enter total figures in this section for only the quarter being reported. Quarters end March 31, June 30, September 30, and December 31. If a central kitchen is approved or assisted, report the number of benefiting schools and membership (enrollment) therein.

"Initiating NSLP Service" refers to a school that does not participate in the National School Lunch Program. Schools in this category have been approved for FSEA funds in order to initiate the National School Lunch Program.

"Initiating SBP Service" refers to a school which has been approved for, or is currently receiving, FSEA funds in order to initiate the School Breakfast Program, without regard to whether or not the school has an existing food service.

"Maintenance and Expansion" refers to a school with an existing meal service which has been approved for FSEA funds for: 1) needed replacement equipment; 2) additional equipment; or, 3) equipment to provide the facilities to receive and serve, or prepare, cook and serve hot meals.

If a school is approved for FSEA for more than one purpose, report that school in the category for which the most funds will be spent.

18a. and 20a. Report only those schools and RCCI's which have received FSEA funds in the same fiscal year that they were approved for such funds. Do not include any unit which was approved in one fiscal year, but received the FSEA funds in a subsequent fiscal year. FOR EXAMPLE: a school which was approved for FSEA funds during the first quarter receives the funds in the fourth quarter. Report this school in the appropriate column in the fourth quarter report. On the other hand, if this approved school will not receive FSEA funds until after the next fiscal year has begun, do not report the school as receiving FSEA funds on any FNS-10 either this year or next year. This also applies to any subsequent revisions of the FNS-10.

In the situation where an approved school will be receiving FSEA funds in more than one quarter of the fiscal year, report that school only once, upon the initial receipt of FSEA funds.

19. and 20. These Items refer to schools and RCCI's determined by the State Agency or FNS Regional Office to be Especially Needy, for which the one-fourth matching cost of the equipment provided under the Food Service Equipment Assistance Program has been waived. Include data for the especially needy program (Item 19) with the data for the regular program (Item 17). Similarly, include data for Item 20 with the data for item 18.

Final data should be reported where possible.

Submitting "revised" reports and a "final report" is as important as sending in the "initial submission." Every effort should be made to mail a final report as soon as possible. If this has not been done within a reasonable period (one month after the mailing of the initial submission might be considered such a period), a revised report should be submitted if there has been any "appreciable" change in any of the data elements. Revised reports should continue to be mailed whenever appreciable changes occur until the final report is submitted. A report should be considered final when it is thought that complete and accurate claim data has been received. However, the fact that a final report has been submitted does not absolve the respondent of the responsibility to submit further reports if changes do occur in any of the data elements. THE NEED FOR A TIMELY FINAL REPORT BASED ON ACTUAL CLAIM DATA IS JUSTIFIED BY THE REQUIREMENT TO USE THIS DATA AS THE BASIS FOR THE AMOUNT OF FUNDS EARNED – TOTAL MEALS BY TYPE TIMES THE "NATIONAL AVERAGE EARNING FACTOR" DETERMINES THIS AMOUNT.

If the number of meals or half-pints served has to be adjusted based on the results of audit findings, the reports for the appropriate months affected should be adjusted accordingly, even if the "final report" has been submitted. This must be done because State earnings are tied directly to the number of federally reimbursable meals or half-pints of milk served.

FNS 13

FORM APPROVED OMB 40R 4086

U.S. DEPARTMENT OF AGRICULTURE
FOOD AND NUTRITION SERVICE

ANNUAL REPORT OF REVENUE AND COST

(FNS School Programs/FNS (CN) Instr. 794-4)

See Instructions on Reverse

No further monies or other benefits may be paid out under these programs unless this report is complete and filed as required by existing regulations (7 CFR-210,215 and 220).

1 STATE

2. STATE AGENCY

3. REPORT FOR SCHOOL YEAR ENDING June 30, 19 ________

4. FINAL REPORT ☐ Yes ☐ No

PROGRAM	NATIONAL SCHOOL LUNCH PROGRAM	SCHOOL BREAK-FAST PROGRAM	SPECIAL MILK PROGRAM (In Schools Only)	NSLP, SBP and SMP TOTAL
NON-FEDERAL REVENUES	(A)	(B)	(C)	(D)
5. State revenues to be counted toward the State Revenue Matching Requirement				
6. Total of: (i) other State revenues not reported in Item 5 above, and (ii) local revenues				
7. Children's payments (included in Item 6 above)				
COSTS	NSLP ONLY	SBP ONLY		▨
8. Program costs at the local level as reported by School Food Authorities	NSLP and SBP (Combined)			▨
Complete Item 9 only if Item 8(A) above has been completed. 9. Are reported costs in Item 8(A) based on the entire costs of operating the NSLP at the local level?	☐ Yes ☐ No		▨	▨

10. CERTIFICATION
I certify to the best of my knowledge and belief that this report is correct and complete.

SIGNATURE	TITLE	DATE

REMARKS

FORM FNS-13 (Rev. 10-73) *Previous editions are obsolete*

INSTRUCTIONS

PURPOSE - This report provides data necessary to monitor the two matching requirements under the National School Lunch Program - the 3 to 1 matching requirement and the State revenue matching requirement. In addition, this report provides a summary of local level costs -

REPORTING PERIOD - The period covered by this report shall be the school year (July 1 - June 30). However, the 1978-79 report shall cover the 21-month period 10-1-77 through 6-30-79. This represents the transition period from fiscal to school year reporting for the NSLP matching requirements as provided by P.L. 95-166. The final report must be mailed by October 31.

STATE AGENCY RESPONSIBILITIES - Each State agency is responsible for submitting a report on "actual data". Further, the State agency must provide, at the request of FNS, adequate corrections and/or clarifications on a timely basis.

All items are self-explanatory except:

Items 5, 6, 7 – Enter the amounts of non-Federal revenue applicable to each Item. If data are available, complete all four Columns (A-D). If data are available for Columns A and D only, please complete these Columns. At a minimum, Column A or D must be completed.

Item 8 – Enter program cost applicable to program administration at the local level. Identify program cost according to guidance contained in FNS Instruction 796-1, Rev. 2, Cost Based Accountability for School Nutrition Programs. Both Items 8A and 8B (NSLP Only & SBP Only) are to be completed if the data are available. If data are available only for the NSLP, complete Item 8A. If only combined cost data are available, then complete NSLP & SBP (Combined).

Item 9 - Check yes if reported costs are based on full cost accounting systems. Otherwise check no.

PREPARATION AND DISTRIBUTION - Prepare in triplicate. Mail original and one copy to the appropriate Regional Office. Retain one copy.

DEFINITIONS

1. **School**
   - a. An education unit of high school grade and under operating under public or nonprofit private ownership in a single building or complex of buildings.
   - b. Also includes residential childcare institutions which are defined as public or licensed nonprofit organizations including, but not limited to, orphanages, homes for the mentally retarded, etc., where children are maintained in residence.
2. **Revenues** - Refers to all non-Federal revenues.
   - a. **State revenues to be counted toward the State revenue matching requirement** - Refers to those State revenues used specifically for school nutrition reimbursable program purposes (NSLP, SBP, and SMP in schools) as defined in Section 210.6 of the NSLP regulations and must be documented by an audit trail to ensure that revenues provided are used for the stated purpose. For example: funds appropriated by a State and used for reimbursing schools on a per-meal basis for meals served could be counted in this item.
   - b. **Other State revenues and local revenues** - Refers to those revenues (including children's payments) expended for the appropriate programs and the certified value of goods and services donated to those programs. Do not include USDA donated commodities, funds expended for land or buildings, or the value of land or rental value of buildings used in these programs.
   - c. **Children's payments** - Refers to payments for paid and reduced-priced meals under the National School Lunch and School Breakfast Programs and paid milk under the Special Milk Program.
3. **COST** - Refers to the total local level program cost associated with the administration of these programs. Do not include the value of Federally donated commodities.

FORM FNS-13 (Rev. 10-79) *Previous editions are obsolete.*

FNS 47

FORM APPROVED OMB NO. 40-R3830

U.S. DEPARTMENT OF AGRICULTURE
FOOD AND NUTRITION SERVICE

ANNUAL REPORT OF MEAL SERVICE IN SCHOOLS

FNS Instruction 794-17

1 COMPLETED BY ("X" ONE)

☐ STATE AGENCY ☐ REGIONAL OFFICE

2 NAME OF STATE

3 DATA CURRENT AS OF

March 31, 19 ____

Prepare in triplicate. Mail ORIGINAL and one copy to the appropriate Regional Office. Retain one copy. Report due April 30.

		PUBLIC SCHOOLS								PRIVATE SCHOOLS							
		SCHOOLS (Excluding Residential Child Care Institutions)				RESIDENTIAL CHILD-CARE INSTITUTIONS				SCHOOLS (Excluding Residential Child Care Institutions)				RESIDENTIAL CHILD-CARE INSTITUTIONS			
		ALL SCHOOLS		SCHOOLS MOVING TOWARD THE SBP[1]		ALL RCCIs		RCCIs MOVING TOWARD THE SBP[1]		ALL SCHOOLS		SCHOOLS MOVING TOWARD THE SBP[1]		ALL RCCIs		RCCIs MOVING TOWARD THE SBP[1]	
	SEE DETAILED INSTRUCTIONS ON REVERSE	NO OF SCHOOLS (a)	MEMBERSHIP (ENROLLMENT) (b)	NO OF SCHOOLS (c)	MEMBERSHIP (ENROLLMENT) (d)	NO OF INST (e)	MEMBERSHIP (ENROLLMENT) (f)	NO OF INST (g)	MEMBERSHIP (ENROLLMENT) (h)	NO OF SCHOOLS (i)	MEMBERSHIP (ENROLLMENT) (j)	NO OF SCHOOLS (k)	MEMBERSHIP (ENROLLMENT) (l)	NO OF INST (m)	MEMBERSHIP (ENROLLMENT) (n)	NO OF INST (o)	MEMBERSHIP (ENROLLMENT) (p)
WITH LUNCH SERVICE	4. In National School Lunch Program (NSLP)																
OTHER LUNCH SERVICE	5. With USDA commodity only assistance																
	6. With other lunch service and eligible for USDA assistance																
	7. With other lunch service but ineligible for USDA assistance																
	8. SUBTOTAL (Lines 4 + 5 + 6 + 7)																
WITHOUT LUNCH SERVICE	9. Eligible for USDA assistance																
	10. Ineligible for USDA assistance																
	11. SUBTOTAL (Lines 9 + 10)																
12. GRAND TOTAL OF UNITS AND MEMBERSHIP (ENROLLMENT) (Lines 8 + 11)																	

REMARKS

FOOTNOTE: [1] Schools and RCCIs reported as moving toward the SBP must also be included in the "All Schools" or "All RCCIs" columns.

I CERTIFY that this report is true and correct to the best of my knowledge and belief.

SIGNATURE	TITLE	AGENCY	DATE

FORM FNS-47 (7-78) *Previous editions are obsolete*

No further monies or other benefits may be paid out under this program unless this report is completed and filed as required by existing regulations (7 CFR 230).

INSTRUCTIONS

PURPOSE – These reports provide data on (1) the lunch status of all schools (including residential child-care institutions) and (2) those schools moving toward the initiation of a School Breakfast Program. These data serve as the basis for (1) the apportionment of "Reserved" Food Service Equipment Assistance funds and (2) administrative information on the status of school food service within each State.

STATE AGENCY RESPONSIBILITIES – Each State agency is responsible for submitting a report based on the best available information. Further, the State agency must provide, at the request of FNS, adequate corrections, clarifications or verification on a timely basis. Failure to comply with these provisions may affect the State agency's share of the apportionment of "Reserved" Food Service Equipment Assistance funds.

All items are self-explanatory except

Items 4 and 5 – Data for National School Lunch and commodity only schools should be comparable to the data on the March FNS-10 report.

6 and 7 – Includes all hot or cold lunch service other than the National School Lunch Program and commodity only lunch service.

7 and 10 – Examples of ineligible schools or residential child-care institutions are those which have restrictive admission policies or those which operate a profit-making food service. Therefore, since these units are not eligible for the SBP, all "Moving Toward the SBP" blocks for items 7 and 10 have been shaded in.

9 through 11 – Due to their very nature, residential child-care institutions are considered with meal (lunch) service. Therefore, all RCCI blocks for items 9, 10, and 11 have been shaded in. All RCCIs should be reported in items 4 through 7.

Each school or RCCI covered by this report should be reported within only *one* of the specific line items (Item 4, 5, 6, 7, 9 or 10) in addition to being included in the appropriate subtotal (Item 8 or 11) and in the Grand Total (Item 12).

DEFINITIONS

1. **WITH LUNCH SERVICE** (Items 4-8) – Refers to schools that make available, to enrolled children, lunches which 1) meet the meal requirements of Section 210.10 of the National School Lunch Program regulations, or 2) in the case of non-NSLP schools, approximate the meal requirements of Section 210.10 of the National School Lunch Program regulations.

2. **WITHOUT LUNCH SERVICE** (Items 9-11) – Refers to schools that do not make available, to enrolled children, lunches approximating the requirements of Section 210.10 of the National School Lunch Program regulations.

3. **MOVING TOWARD THE SBP** – Refers to schools for which bona fide written commitments of intent to initiate the School Breakfast Program have been made during the 12 month period (April 1-March 31) immediately preceding the date of the report being filed. Examples of such commitments include signed agreements or applications to participate in the Program and letters of intent to initiate the Program. Schools in this category have determined that it is feasible to initiate the Program, and have fulfilled the necessary local prerequisites prior to submitting the bona fide written commitment.

4. **SCHOOL**
   a. An educational unit of high school grade or under operating under public or nonprofit private ownership in a single building or complex of buildings. When separately administered elementary and secondary grade levels are housed in the same building, each is considered a separate school. When both levels are administered as one unit, it should be considered a single school.

   b. Also includes residential child-care institutions as defined below.

5. **RESIDENTIAL CHILD CARE INSTITUTION** – A public or licensed nonprofit private organization including, but not limited to, orphanages, homes for the mentally retarded, etc., where children are maintained in residence.

6. **MEMBERSHIP (ENROLLMENT)** – A pupil is a member of a school from the date he presents himself at school and is placed on the current roll until he permanently leaves the school for one of the causes recognized as sufficient by the State. The date of permanent withdrawal should be the date on which it is officially known that the pupil has left school, and not necessarily the first day after the date of last attendance. Membership is obtained by adding the total original entries and the total reentries and subtracting the total withdrawals; it may also be obtained by adding the total number present and the total number absent. This term is also known as the number belonging. This same definition may be applied to residential child-care institutions.

SF 183

REQUEST FOR PAYMENT ON LETTER OF CREDIT
AND
STATUS OF FUNDS REPORT

SECTION I—REQUEST FOR PAYMENT

AGENCY STATION SYMBOL	LETTER OF CREDIT NUMBER	DOCUMENT NUMBER	AMOUNT REQUESTED $
NAME AND ADDRESS OF U.S. AGENCY	NAME AND ADDRESS OF DRAWER		PAID BY *(Treasury Use Only)*
NAME AND ADDRESS OF TREASURY DISBURSING OFFICE	MAKE TREASURY CHECK PAYABLE TO:		VOUCHER APPROVED *(Treasury Use Only)*
			CHECK NUMBER *(Treasury Use Only)*

SECTION II—STATUS OF FEDERAL FUNDS *(Must Be Completed By Drawer)*

ITEMS	ESTIMATED NO. OF DAYS SUPPLY	AMOUNT
1. FEDERAL FUNDS ON HAND *(Beginning of Federal Fiscal Year)*	▨	$
2. ADD: ADVANCES RECEIVED, FISCAL YEAR TO DATE	▨	
3. ADD: COLLECTIONS, REFUNDS, AND/OR MISCELLANEOUS RECEIPTS	▨	
4. Subtotal	▨	
5. LESS: ACTUAL DISBURSEMENTS, FISCAL YEAR TO DATE	▨	
6. FEDERAL FUNDS ON HAND AT TIME OF THIS REQUEST		
7. ADD: AMOUNT OF THIS REQUEST FOR PAYMENT		
8. ADD: UNPAID REQUESTS FOR PAYMENT PREVIOUSLY SUBMITTED	▨	
9. TOTAL →		$
10. OUTSTANDING ADVANCES TO SUB-GRANTEES—NUMBER TOTAL $		*Treasury Use Only*

SECTION IIA—REMARKS *(Drawers Use)*

SECTION III—CLASSIFICATION OF THE AMOUNT OF THIS REQUEST *(Must Be Completed By Drawer)*

PROGRAM, GRANT NO. OR OTHER IDENTIFYING NO.	AMOUNT	PROGRAM, GRANT NO. OR OTHER IDENTIFYING NO.	AMOUNT
	$		$

TOTAL *(Must Agree with Amount of this Request for Payment)* $

SECTION IV—CERTIFICATION *(Must Be Completed By Drawer)*

I certify that this Request for Payment has been drawn in accordance with the terms and conditions of the Letter of Credit cited and that the amount for which drawn is proper for payment to the drawer or for credit to the account of the drawer at the drawer's bank. I also certify that the data reported above is correct and that the amount of the Request for Payment is not in excess of current needs.

DATE	SIGNATURE	TITLE
DATE	COUNTERSIGNATURE	TITLE

Standard Form 183
December 1975
1 Treasury FRM 6-2000

ORIGINAL—Drawer will forward this copy to Treasury Disbursing Office.

183-101

[illegible]

SF 269

110

FINANCIAL STATUS REPORT

(Follow instructions on the back)

1. FEDERAL AGENCY AND ORGANIZATIONAL ELEMENT TO WHICH REPORT IS SUBMITTED

2. FEDERAL GRANT OR OTHER IDENTIFYING NUMBER

OMB Approved No. 80-R0180

PAGE OF PAGES

3. RECIPIENT ORGANIZATION *(Name and complete address, including ZIP code)*

4. EMPLOYER IDENTIFICATION NUMBER

5. RECIPIENT ACCOUNT NUMBER OR IDENTIFYING NUMBER

6. FINAL REPORT ☐ YES ☐ NO

7. BASIS ☐ CASH ☐ ACCRUAL

8. PROJECT/GRANT PERIOD *(See instructions)*
FROM *(Month, day, year)*
TO *(Month, day, year)*

9. PERIOD COVERED BY THIS REPORT
FROM *(Month, day, year)*
TO *(Month, day, year)*

10. STATUS OF FUNDS

PROGRAMS/FUNCTIONS/ACTIVITIES ►	*(a)*	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	TOTAL *(g)*
a. Net outlays previously reported	$	$	$	$	$	$	$
b. Total outlays this report period							
c. *Less:* Program income credits							
d. Net outlays this report period *(Line b minus line c)*							
e. Net outlays to date *(Line a plus line d)*							
f. *Less:* Non-Federal share of outlays							
g. Total Federal share of outlays *(Line e minus line f)*							
h. Total unliquidated obligations							
i. *Less:* Non-Federal share of unliquidated obligations shown on line h							
j. Federal share of unliquidated obligations							
k. Total Federal share of outlays and unliquidated obligations							
l. Total cumulative amount of Federal funds authorized							
m. Unobligated balance of Federal funds							

11. INDIRECT EXPENSE
a. TYPE OF RATE *(Place "X" in appropriate box)* ☐ PROVISIONAL ☐ PREDETERMINED ☐ FINAL ☐ FIXED
b. RATE
c. BASE
d. TOTAL AMOUNT
e. FEDERAL SHARE

12. REMARKS: *Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation.*

13. CERTIFICATION
I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL

DATE REPORT SUBMITTED

TYPED OR PRINTED NAME AND TITLE

TELEPHONE *(Area code, number and extension)*

269-101

STANDARD FORM 269 (7-76)
Prescribed by Office of Management and Budget
Cir. No. A-110

INSTRUCTIONS

Please type or print legibly. Items 1, 2, 3, 6, 7, 9, 10d, 10e, 10g, 10i, 10l, 11a, and 12 are self-explanatory, specific instructions for other items are as follows.

Item	*Entry*
4	Enter the employer identification number assigned by the U.S. Internal Revenue Service or FICE (institution) code, if required by the Federal sponsoring agency.
5	This space is reserved for an account number or other identifying numbers that may be assigned by the recipient.
8	Enter the month, day, and year of the beginning and ending of this project period. For formula grants that are not awarded on a project basis, show the grant period.
10	The purpose of vertical columns (a) through (f) is to provide financial data for each program, function and activity in the budget as approved by the Federal sponsoring agency. If additional columns are needed, use as many additional forms as needed and indicate page number in space provided in upper right; however, the totals of all programs, functions or activities should be shown in column (g) of the first page. For agreements pertaining to several Catalog of Federal Domestic Assistance programs that do not require a further functional or activity classification breakdown, enter under columns (a) through (f) the title of the program. For grants or other assistance agreements containing multiple programs where one or more programs require a further breakdown by function or activity, use a separate form for each program showing the applicable functions or activities in the separate columns. For grants or other assistance agreements containing several functions or activities which are funded from several programs, prepare a separate form for each activity or function when requested by the Federal sponsoring agency.
10a	Enter the net outlay. This amount should be the same as the amount reported in Line 10e of the last report. If there has been an adjustment to the amount shown previously, please attach explanation. Show zero if this is the initial report.
10b	Enter the total gross program outlays (less rebates, refunds, and other discounts) for this report period, including disbursements of cash realized as program income. For reports that are prepared on a cash basis, outlays are the sum of actual cash disbursements for goods and services, the amount of indirect expense charged, the value of in-kind contributions applied, and the amount of cash advances and payments made to contractors and subgrantees. For reports prepared on an accrued expenditure basis, outlays are the sum of actual cash disbursements, the amount of indirect expense incurred, the value of in-kind contributions applied, and the net increase (or decrease) in the amounts owed by the recipient for goods and other property received and for services performed by employees, contractors, subgrantees, and other payees.
10c	Enter the amount of all program income realized in this period that is required by the terms and conditions of the Federal award to be deducted from total project costs. For reports prepared on a cash basis, enter the amount of cash income received during the reporting period. For reports prepared on an accrual basis, enter the amount of income earned since the beginning of the reporting period. When the terms or conditions allow program income to be added to the total award, explain in remarks, the source, amount and disposition of the income.
10f	Enter amount pertaining to the non-Federal share of program outlays included in the amount on line e.
10h	Enter total amount of unliquidated obligations for this project or program, including unliquidated obligations to subgrantees and contractors. Unliquidated obligations are: Cash basis—obligations incurred but not paid. Accrued expenditure basis—obligations incurred but for which an outlay has not been recorded. Do not include any amounts that have been included on lines a through g. On the final report, line h should have a zero balance.
10j	Enter the Federal share of unliquidated obligations shown on line h. The amount shown on this line should be the difference between the amounts on lines h and i.
10k	Enter the sum of the amounts shown on lines g and j. If the report is final the report should not contain any unliquidated obligations.
10m	Enter the unobligated balance of Federal funds. This amount should be the difference between lines k and l.
11b	Enter rate in effect during the reporting period.
11c	Enter amount of the base to which the rate was applied.
11d	Enter total amount of indirect cost charged during the report period.
11e	Enter amount of the Federal share charged during the report period. If more than one rate was applied during the project period, include a separate schedule showing bases against which the indirect cost rates were applied, the respective indirect rates the month, day, and year the indirect rates were in effect, amounts of indirect expense charged to the project, and the Federal share of indirect expense charged to the project to date.

☆ U.S. GPO: 1976-0-210-774/1045

FNS 806

Previous editions are obsolete

Form Approved OMB No. 40-R2470

FORM FNS [illegible]
(5-79)

U.S. DEPARTMENT OF AGRICULTURE
FOOD AND NUTRITION SERVICE

School Lunch, Breakfast and Special Milk Programs
MONTHLY REPORT

FNS INSTR. [illegible]

Read INSTRUCTIONS on reverse carefully before completing form.

PLACE "X" IN BOX IF THIS IS AN ADJUSTED CLAIM ☐

Check for accuracy and make any changes that are necessary.

1. AGREEMENT NUMBER:

2. NAME AND ADDRESS OF SCHOOL FOOD AUTHORITY, INSTITUTION OR SPONSORING AGENCY

INSTRUCTIONS: Submit original and one copy to the FNS Regional Office which administers your program not later than the 10th of the month following the month covered by the claim. A copy must be retained by the sponsor. Record all entries in the right most positions in the boxes provided for each item.

NOTE: Do not enter cents in Items 13c, 13, and 14. All amounts must be rounded to the nearest dollar. For example:
$91.00 to $91.49 must be shown as 0 0 9 1 0 0
$91.50 to $92.00 must be shown as 0 0 9 2 0 0

3. MONTH AND YEAR CLAIMED — MONTH 21 22 — YEAR 23

4. OPERATING DAYS FOR MONTH CLAIMED — 24 25

5. AVERAGE DAILY ATTENDANCE — 26 27 28 29 30 31

FOR FNS USE ONLY — Y MM DD — 32 33 34 35 36

NATIONAL SCHOOL LUNCH PROGRAM

6. Total of all lunches served to children *(Including Items 7 and 8)* 37 38 39 40 41 42

7. Total reduced price lunches 43 44 45 46 47 48

8. Total free lunches 49 50 51 52 53 54

SCHOOL BREAKFAST PROGRAM

9. Total of all breakfasts served to children *(Including Items 10 and 11)* 55 56 57 58 59 60

10. Total reduced price breakfasts 61 62 63 64 65 66

11. Total free breakfasts 67 68 69 70 71 72

SPECIAL MILK PROGRAM (YEAR-ROUND AND SUMMER OPERATIONS)

0 1 — 79 80

12. Number of ½ pints served TO CHILDREN that were:

(a) Paid for by children *(Do not include ½ pints served with meals claimed above)* 24 25 26 27 28 29 30

(b) Free to children approved for free milk *(Do not include ½ pints served with meals claimed above)* 31 32 33 34 35 36 37

(c) Total cost of milk purchased *(Cost of all ½ pints reported in 12 d after discount)* . . . . 38 39 40 41 42 43 — 0 0

(d) Total number of ½ pints of milk purchased *(Include milk purchased for meal service as reported in Items 6 and 9)* 44 45 46 47 48 49 50

13. TOTAL COST THIS MONTH FOR ALL FOOD PROGRAMS *(Includes a la carte and Special Milk Program)* . . . . 51 52 53 54 55 56 57 — 0 0

14. INCOME RECEIVED THIS MONTH FROM A la carte SALES *(Includes income from adult meals and special functions)* . . . . 58 59 60 61 62 63 64 — 0 0

15. Estimate the number of children eligible for free and reduced meals under the school's approved eligibility standards *(March and October reports only)* 65 66 67 68 69 70 71

16. Number of children approved for free meals *(Must be completed on all reports)* . . . . 72 73 74 75 76 77 78 — 0 2 — 79 80

17. Number of children approved for reduced price meals *(Must be completed on all reports)* 24 25 26 27 28 29 30

I CERTIFY that to the best of my knowledge and belief, this claim is true and correct in all respects, that records are available to support this claim; that is in accordance with the terms of existing Agreement(s); and that payment therefor has not been received. I recognize that I will be fully responsible for any excess amounts which may result from erroneous or neglectful reporting herein.

18. SIGNATURE ON BEHALF OF SCHOOL FOOD AUTHORITY, INSTITUTION OR SPONSORING AGENCY

19. TITLE

20. PREPARATION DATE — MONTH DAY YEAR — 72 73 74 75 76

FNS USE ONLY — AVC — 0 3 — 77 78 79 80

ALL RECEIPTS, INVOICES, AND OTHER EVIDENCE OF PURCHASE MUST BE RETAINED AND AVAILABLE FOR FURTHER AUDIT FOR A PERIOD OF 3 YEARS AND 3 MONTHS AFTER THE END OF THE FISCAL YEAR TO WHICH THEY PERTAIN.

NO FURTHER MONIES OR OTHER BENEFITS MAY BE PAID OUT UNDER THIS PROGRAM UNLESS THIS REPORT IS COMPLETED AND FILED AS REQUIRED BY EXISTING REGULATIONS. (7 C.F.R. 210, 215, 220)

FORM FNS-[illegible] (5-79)

INSTRUCTIONS

SPECIAL NOTE: AN ADJUSTED CLAIM completely voids all previous claims for the same month. Therefore, you should include ALL of your reporting data for the entire month's operation.

GENERAL

Report data for all programs in which school, institution or camp participates. Include data for one calendar month only, unless otherwise authorized by the Food and Nutrition Service Regional Office. Payment will be computed by USDA based on rates in effect.

All participants should complete sections of this claim as they apply to your operation. YOUR CLAIM WILL BE RETURNED FOR CORRECTION if not properly completed. *BE SURE TO SIGN AND DATE THIS CLAIM BEFORE MAILING* TO AVOID DELAYING YOUR PAYMENT CHECK.

ITEM

1. Your agreement number has already been entered on your claim. Check to be sure it's correct. The agreement number can be found on your copy of the agreement. If it has not been entered, please enter the agreement number.

2. The name and address as shown in your agreement(s) has been preprinted. Check for accuracy and make any changes that are necessary.

3. Enter the number of the month and year this claim covers.

Example: January 1979 - 01 79

4. Enter actual number of days food and/or milk was served.

5. Compute average daily attendance by adding daily attendance for the month and dividing that total by the number of days of operation during the same month.

NATIONAL SCHOOL LUNCH PROGRAM

6. Enter total of *ALL* lunches served to children, including those served free and at a reduced price.

7-8 Enter in Item 7 the number of reduced price lunches served and in Item 8 the number of free lunches served. These represent lunches served to children who are determined to be eligible for such meals under the school's approved free and reduced price meal policy statement.

SCHOOL BREAKFAST PROGRAM

9 Enter total of *ALL* breakfasts served to children, including those served free and at a reduced price.

10-11 Enter in Item 10 the number of reduced price breakfasts served and in Item 11 the number of free breakfasts served. These represent breakfasts served to children who are determined to be eligible for such meals under the school's approved free and reduced price meal policy statement.

12 SPECIAL MILK PROGRAM
(YEAR-ROUND AND SUMMER OPERATIONS)

NOTE: This section to be completed by *ALL* Special Milk Program participants.

a) Enter total number of 1/2 pints paid for by children. Do *not* include 1/2-pints served with lunch and/or breakfast.

b) This item for *schools or sponsors approved* for free milk. Enter number of 1/2-pints served to children *approved* for free milk. Do not include 1/2-pints served with lunch and/or breakfast.

c) Enter the actual total cost of milk paid to milk distributor after discount. (Cost of all 1/2-pints purchased as reported in Item 12d. Do not enter cents.

d) Enter total number of *all* milk 1/2-pints purchased including that purchased for meal service as reported under Items 6 and/or 9.

FINANCIAL DATA

NATIONAL SCHOOL LUNCH AND/OR BREAKFAST SCHOOLS ONLY

NOTE: Do not enter cents in Items 13 thru 14. All amounts must be rounded to the nearest dollar. For example, $91.00 to $91.49 must be shown as $91; $91.50 to $92.00 must be shown as $92.

ITEM

13 Enter the total cost of operating all food service programs. Costs to be reported in this item include cost of food used (including milk), gross wages, plus employers contributions toward social security, insurance, retirement, and other employee benefits. Also include the cost of expendable equipment, indirect costs, the cost or depreciation of nonexpendable equipment purchased with non-Federal funds and any other cost of operating the food service.

14 Enter all income received from food service other than children's payments for meals and 1/2 pints claimed in items 6 thru 12. Include a la carte and adult payments as well as any contributions received from individuals, organization, and governmental or sponsoring agencies. Do not include loans, advances, or payments received from USDA.

NOTE: Please contact your FNS Regional Office if more clarification is needed regarding identification of eligible costs.

15 On March and October reports only estimate the number of children eligible for free and reduced price meals under the schools approved eligibility standards.

16-17 Enter the number of children who have current and complete applications on file, and who have been approved for free and reduced price meal service as of the close of the reporting month.

18-20 Must be completed for payment to be disbursed.

GPO 941 782

SUMMARY OF CHAPTER II. METHODS FOR ASSESSING THE NUTRITIONAL STATUS OF CHILDREN

In this chapter we review the research methods used in assessments of nutritional status with an emphasis on the literature relevant to dietary, biochemical and anthropometric measurements of school-age children. We also evaluate the strengths and limitations of these methods in terms of their potential use for a large-scale study of school nutrition programs. The criteria used are reliability and validity, cooperation of subjects, feasibility in large-scale surveys, and cost. The standards used to interpret the findings of nutrition surveys are also discussed.

WHAT METHODS HAVE BEEN USED TO ASSESS THE NUTRITIONAL STATUS OF SCHOOL CHILDREN, AND WHAT ARE THEIR STRENGTHS AND LIMITATIONS?

To answer this question, several subquestions were identified and the literature pertinent to each was separately reviewed. The questions and the major findings of the review are summarized below.

A. *What Dietary Measures Have Been Used to Assess the Nutritional Status of School Children and What Are Their Strengths and Limitations?*

Dietary methods provide information about the kinds and quantities of foods consumed by individuals and groups of subjects. Methods commonly used in surveys include the 24-hour recall, weighed food record, estimated food record, diet history and food frequency.

In the 24-hour recall method, subjects attempt to remember the kinds and quantities of foods eaten during the previous 24-hour period. The 24-hour recall is generally accepted as a valid method for obtaining quantifiable dietary information from groups (Young et al., 1952b; Chalmers et al., 1952). It cannot be used to assess the dietary intake of individuals, since variations in the diets of most individuals are too great to reveal the usual or typical intake in a one-day period (Chalmers et al., 1952; Balogh et al., 1971).

There is evidence that the 24-hour recall method can be used with children who are at least nine years of age, but that younger children may not be able to provide accurate information on either the kinds or quantities of foods they have eaten (Emmons & Hayes, 1973). Some research suggests that mothers may be no better at recalling the food intakes of their children (Emmons & Hayes, 1973; Youland & Engle, 1976). Therefore, it is recommended that the mother (or another knowledgeable caretaker) and the child be interviewed together when the 24-hour recall is used with children under nine years of age.

There are a number of protocols for the 24-hour recall that can be adapted for use in an evaluation of school nutrition programs. Protocols from the Health and Nutrition Examination Survey (Youland & Engle, 1976) and the Bogalusa Heart Study (Frank et al., 1977) have been used on large samples which included school age children and have been tested for reliability. Both protocols include probing questions and food models to improve the subject's ability to recall foods eaten during the previous 24 hours and estimate the size of portions.

The 24-hour recall is subject to certain limitations. Compared with other dietary assessment methods, the 24-hour recall underestimates nutrient intake (Adelson, 1960; Acheson, 1980; Thompson, 1958; Madden et al., 1976). Consequently, the 24-hour recall will overestimate the prevalence of low intakes in the population compared with dietary standards (Hegsted, 1975). Also, the 24-hour recall has been shown to exhibit a phenomenon called the "flat-slope syndrome" (Gersovitz et al., 1978). This occurs because individuals with low intakes tend to overreport and individuals with high intakes tend to underreport their true consumption. As a result, differences in the average intakes of groups may be underestimated when intakes obtained by the 24-hour recall are compared.

Weighed or estimated food records can also be used to assess the dietary intake of groups, and may yield valid estimates for individuals, provided that the period of observation is sufficiently long. In the weighed method, investigators or the subjects themselves weigh food items on a scale and record quantities at the time food is eaten. In the estimated method, subjects determine the quantities of food consumed using household measuring devices such as cups and spoons instead of scales.

Chalmers et al. (1952) suggest that it may be necessary to keep records for periods up to 14 consecutive days to obtain estimates of calories, protein and most vitamins and minerals for individuals. This time period is necessary to ensure that the measured intake of an individual is within 15 percent of actual intake. Longer periods may be required for nutrients such as vitamin A, ascorbic acid, sodium and cholesterol, which exhibit large day-to-day variations in the diets of individuals. Season of the year can also affect intake. To compensate for this factor and to obtain a more long-term estimate of individual intake, some investigators recommend taking repeated one-day measurements (either food records or 24-hour recalls) on random days each month over an entire year (Balogh et al., 1971).

The diet history has also been used to assess the dietary intake of individuals (Beal, 1976; Mann, 1962; Reshef et al., 1972). Protocols vary; however, the original method consists of an assessment of the individual's social and medical history and a recall of intake for a typical day, which is validated by a cross-check on the frequency of consuming various kinds of foods and a three-day food record (Burke, 1947). As with the 24-hour recall, food models are used to assist the subject with the estimation of portion sizes (Moore et al., 1967). The method has been used in longitudinal studies with children (Beal, 1967). It appears that the diet history tends to overestimate nutrient intake compared with weighed or estimated food records (Young et al. 1952a; Lubb, 1968).

The food frequency method has been used as a validation procedure for the 24-hour recall (Youland & Engle, 1976) and independently to obtain estimates of the usual intake of individuals (Balogh et al., 1968; Abrahamson et al., 1963; Wiehl & Reed, 1960). In this method, subjects are asked how often they consume foods on a specified list. Some studies also assess the typical quantities consumed. Researchers testing this method have generally concluded that while the food frequency can be used to obtain qualitative information about the kinds of foods eaten (Stefanik & Trulson, 1962), it cannot provide accurate information on quantities. (Epstein et al., 1970; Hunt et al., 1979). There is no evidence in the literature that children are able to provide reliable and valid data using the food frequency method.

The analysis of dietary data can take several forms. Some analyses seek only to evaluate the number of servings eaten from various food groups. This gives only a crude estimate of the adequacy of dietary intake (King et al., 1978).

To obtain more precise estimates, quantities of foods reported by the subjects are converted into their nutrient equivalents. The most accurate means of obtaining these estimates is to perform chemical analyses directly on the food; however, the use of food composition tables that compile nutrient data from previous research is the only practical method in surveys involving large numbers of subjects (Marr, 1971). Computerized data bases for food composition contain values from the U.S. Department of Agriculture, food manufacturers and other published sources. Not all data bases contain values for all nutrients, and therefore they vary in their scope, validity, and completeness. Data on nutrients such as folic acid, sodium, magnesium, zinc, copper, and vitamin E and on fiber vary considerably according to source.

The commonly accepted method of evaluating nutrients available from dietary intake is to compare them with the Recommended Dietary Allowances (RDA). The RDA are guidelines set by the Food and Nutrition Board of the National Academy of Science. According to the most current research on nutrient requirements, these guidelines are believed to provide adequate nutrition for most healthy persons in the United States (National Research Council, 1980). When intakes of the subjects are compared with the appropriate RDA for age and sex, estimates can be made of the proportion of the population whose intakes fall below recommended levels for each nutrient. This gives an indication of the risk for malnutrition exhibited by the group; however, individual intakes that do not meet the RDA cannot necessarily be judged as deficient. Further information from biochemical, clinical and anthropometric assessments is needed to evaluate the status of individuals.

B. *What Biochemical Measures Have Been Used to Assess the Nutritional Status of School Children and What Are Their Strengths and Limitations?*

Biochemical analyses of blood, urine, hair and saliva can provide evidence of specific nutrient levels in the body. Tests are performed to assess the status of protein, vitamins and minerals. Not all analyses are appropriate for large-scale field surveys (Christakis, 1973).

Iron deficiency, as a cause of anemia in children, is assessed in almost all surveys. Of the various methods of assessing iron status, the two tests that are performed most often are hemoglobin and hematocrit determinations. Hemoglobin is an iron-containing substance in red blood cells which transports oxygen throughout the body. Hematocrit is a measure of the packed volume of red cells in a specified quantity of blood. In iron deficiency, both of these measures are reduced.

Although hemoglobin and hematocrit tests are both well standardized and relatively inexpensive, they have limitations. Impairment of hemoglobin synthesis and of the formation of red blood cells occurs when body stores of iron are low. Therefore, reduced hemoglobin and hematocrit values occur in the relatively late stages of iron deficiency (Koerper & Dallman, 1977). There is also evidence that standards currently in use for hemoglobin may not be appropriate for black children (Dallman et al., 1980). Hematocrits are considered to be less reliable indicators of iron status because they frequently produce false negative results when used to diagnose anemia (Center for Disease Control, 1977).

Serum ferritin is a more sensitive measure of iron status because it measures iron stores (Woodruff, 1977). The major limitation of the method for use in large-scale studies is the cost and availability of laboratory equipment needed to perform the analysis (Dallman et al., 1980). For this reason, serum ferritin has not been assessed in large-scale nutrition surveys.

Other biochemical measures can be used to identify children at risk of deficiencies of nutrients such as protein, vitamin A, ascorbic acid, thiamin, riboflavin, and trace minerals (e.g., copper and zinc). The findings of surveys that have assessed these nutrients in children and examples of nutritional disorders that result from deficiencies are discussed in Chapter III. Tests using samples of hair or saliva are available, but tests using blood or urine samples are either the most valid means of assessment or the most practical methods in large field studies (Pearson, 1962; Hambridge, 1973; Greger & Sickles, 1979).

Serum levels of protein and vitamin A are indicators of long-term status. Levels are generally not reduced until body stores are depleted; both measures can be affected by factors, such as infection, which are unrelated to nutrition (Sauberlich, 1974).

Serum levels of ascorbic acid reflect recent dietary intake (Sauberlich, 1974). Therefore, this measure can fluctuate in individuals more rapidly than levels of serum protein or vitamin A. Tests that measure the more long-term status of ascorbic acid are too expensive to be used in the field (Pearson, 1962).

Serum protein, ascorbic acid and vitamin A have been assessed in large-scale surveys, and standards exist for the evaluation of data from children. Serum levels of trace minerals have not been assessed in any of the major large-scale nutrition surveys in the United States. Also, standards for zinc and copper levels in children are not well established.

Thiamin and niacin are usually assessed by the levels excreted in the urine. These levels fluctuate during the day and may be influenced by non-nutritional factors (Sauberlich et al., 1974). More valid tests using blood samples are not feasible in large-scale surveys.

Recently, there has been considerable interest in the use of biochemical methods to evaluate the effects of excessive consumption of dietary constituents such as cholesterol, fat, and sugar. The relationships between dietary intake and blood levels of these constituents in children is currently being investigated in several long-term studies (Berenson, 1980). Until more is known about these relationships, it does not appear reasonable to perform biochemical assessments of these constituents as measures of school nutrition program impacts.

The collection of biochemical samples is inconvenient and, in the case of blood, painful for the subjects. The potential for high rates of noncooperation is a major drawback in the use of biochemical methods. Legal problems can also be encountered in attempts to collect biological samples from children at school. Depending upon the tests being conducted, the reliability of results from different laboratories can be poor, if proper procedures are not taken for standardization (Christakis, 1973). Cost can also be a factor if specialized laboratory equipment must be purchased for the study.

C. *What Anthropometric Measures Have Been Used to Assess the Nutritional Status of School Children and What Are Their Strengths and Limitations?*

Anthropometric measures are used to assess the sufficiency of calorie and protein intake as reflected by the growth and development of children (Roa & Singh, 1970). Height and weight measure body size. Fatfold and circumference measures are indirect indicators of body composition. Other techniques such as radiography, ultrasound and laboratory methods also provide evidence of body composition, but at present, these methods are either too expensive or impractical to use in large field surveys (Haas, 1979).

Standards from the National Center for Health Statistics are available for interpreting height-for-age and weight-for-age of children up to 18 years, and weight-for-height up to the age of 10 years in girls and 11-1/2 years in boys (NCHS, Ser. 11, No. 165, 1977). There are no comparable standards for fatfold and circumference measures, but several sets of reference data, such as those from the Ten State Nutrition Survey and the various cycles of the Health Examination Survey, can be used.

In addition to comparing anthropometric data with standards and data from reference populations, the various measurements can be used in indices and equations. Indices such as the "ponderal index" assess relative weight by controlling the effects of height on overall body mass. Equations using height, weight and triceps fatfold attempt to predict the weight or percentage of total body fat. Equations using the triceps fatfold and the mid-upper-arm circumference estimate muscle size. The indices and equations contained in published reports should not be used unless they are derived from nationally representative samples of children or from samples similar in age, sex and genetic characteristics to the population being studied (Smith & Boyce, 1977; Durant & Linder, 1981).

The major validity problems encountered with anthropometric measures focus on whether cross-sectional or longitudinal data are being examined and whether standards are applicable to all racial-ethnic groups.

Cross-sectional data can be used to evaluate the status of individuals and groups of prepubescent children. At puberty, children experience spurts in height and weight which vary in onset, duration, and intensity. The onset of this growth spurt depends more on biological age than on chronological age. Consequently, studies assessing growth of individuals during adolescence cannot make valid interpretations for height and weight without data on biological age (NCHS, Ser. 11, No. 132, 1974). There is evidence that interpretations of fatfold measurements during this period require data on biological age as well (Young et al., 1968). Such data are not necessary in cross-sectional studies of groups containing adolescents if it can safely be assumed that the patterns of sexual maturation in the group do not differ from the reference population; however, in longitudinal studies, biological age should be assessed. Longitudinal studies should also control for the normal growth that takes place between data collection points, as well as seasonal variations that are known to occur in growth in height (Prader et al., 1963) and weight (Malina, 1971).

Genetic factors can also confound the interpretation of anthropometric data. Differences in height, weight and fatfold measurements have been discovered among black, white, Asian, and Hispanic children, suggesting that different sets of standards for the evaluation of nutritional status may be required (Garn, 1979; Zavaleta & Malina, 1980). While this issue is of theoretical importance, no separate standards by race currently exist.

Measurement error can be a major reliability problem in anthropometry, especially when several teams of data collectors are used in the survey (Gavan, 1950; NCHS, Ser. 11, No. 120, 1972). Quality control and training procedures are important features in the design of anthropometric studies (Zerfas, 1979). These factors can add to the cost of anthropometric methods; however, in general, these methods are less expensive than those used in the collection and analysis of dietary and biochemical information. There are few reported problems in obtaining anthropometric measures from children, but some adolescents may refuse to submit to an examination to determine biological age.

DISCUSSION AND RECOMMENDATIONS

Cross-sectional studies of the nutritional impacts of school nutrition programs should be conducted on nationally representative samples of children. The recommended methods of nutritional status assessment are the 24-hour recall of dietary intake and anthropometric measures of height, weight, triceps fatfold and mid-upper-arm circumference. Biochemical tests are not recommended, due to potential problems of cooperation of subjects, cost considerations, and the limited value of biochemical data in assessing program impacts.

Longitudinal studies can also be conducted to assess program impacts, but the logistics of such studies may make it impossible to conduct them on nationally representative samples. However, longitudinal studies potentially can provide information about changes in the nutritional status of individual children as a result of program participation which cannot be provided by cross-sectional data. In such studies, the diet history should be used in place of the 24-hour recall as the means of dietary assessment in order to obtain a more valid estimate of typical intake. The same anthropometric measures as those used in cross-sectional surveys are recommended, but the anthropometric measures should be accompanied by growth histories and, if the sample includes adolescents, by examinations for biological age. To the extent possible, biochemical measures should be used to identify children at risk of nutrient deficiencies. Assessment of iron status should receive priority. Serum ferritin is the preferred method of assessing iron stores. Hemoglobin or hematocrits may also be included to diagnose more severe deficiencies. Depending on the population being studied, biochemical tests might also include serum protein, vitamin A, ascorbic acid, copper or zinc.

CHAPTER II. METHODS FOR ASSESSING THE NUTRITIONAL STATUS OF CHILDREN

Joyce Vermeersch

INTRODUCTION

Purpose of the Review

This chapter is a review of the literature on methods of assessing the nutritional status of school-age children. It is intended to provide background information for evaluating the strengths and weaknesses of existing research investigating the impacts of school nutrition programs on the nutritional status of participants. It also serves as a basis for selecting appropriate methods to use in future studies of these programs.

The review is limited to methods that are commonly used in field surveys. It does not include methods that are used primarily in metabolic laboratory research or as diagnostic tests in hospitals.

References for the review were selected from bibliographies in recent review articles and textbooks on nutritional status assessment. The list of references is not exhaustive, but it includes the major works that have contributed to the field.

References dealing with the nutritional assessment of children are discussed in detail. Methods developed from studies of adult subjects are also discussed. These references are included because some methods of nutritional status assessment have not been sufficiently investigated in children; studies involving adults provide the only available information.

Definition of Nutritional Status

For purposes of this review, nutritional status is defined as "the health condition of an individual as influenced by the intake and utilization of nutrients" (Christakis, 1973). Poor nutritional status or "malnutrition" can result from either a deficiency or an excess of nutrients in relation to body requirements. The body's requirements for nutrients are influenced by a number of physical factors such as age, sex, body size, and physiological state. Some requirements are further influenced by the level of physical activity and the environment in which a person lives (National Research Council, 1980).

The development of malnutrition progresses in stages. It begins with improper dietary intake; this is followed by alterations in the level or activity of nutrients in the body. These alterations progress to the appearance of the clinical symptoms of disease and, ultimately, permanent disability or death (Hegsted, 1975).

Measures of Nutritional Status

Nutritional status is a complex dynamic biological state. It cannot be measured directly, but must be inferred from the examination of a combination of indirect indicators. The indicators that have been used to measure nutritional status parallel the natural history of malnutrition. They are traditionally classified as dietary, biochemical, anthropometric, and clinical methods of assessment. The relationships between the various parameters and measures of nutritional status are diagrammed in Figure II-1.

Dietary methods determine the types, quantities, or frequencies of foods consumed by individuals or groups in order to describe the general quality of the diet or to estimate the amounts of nutrients available from food. Amounts of nutrients available from food can be compared with standards for dietary intake that are derived from research on human nutrient requirements.

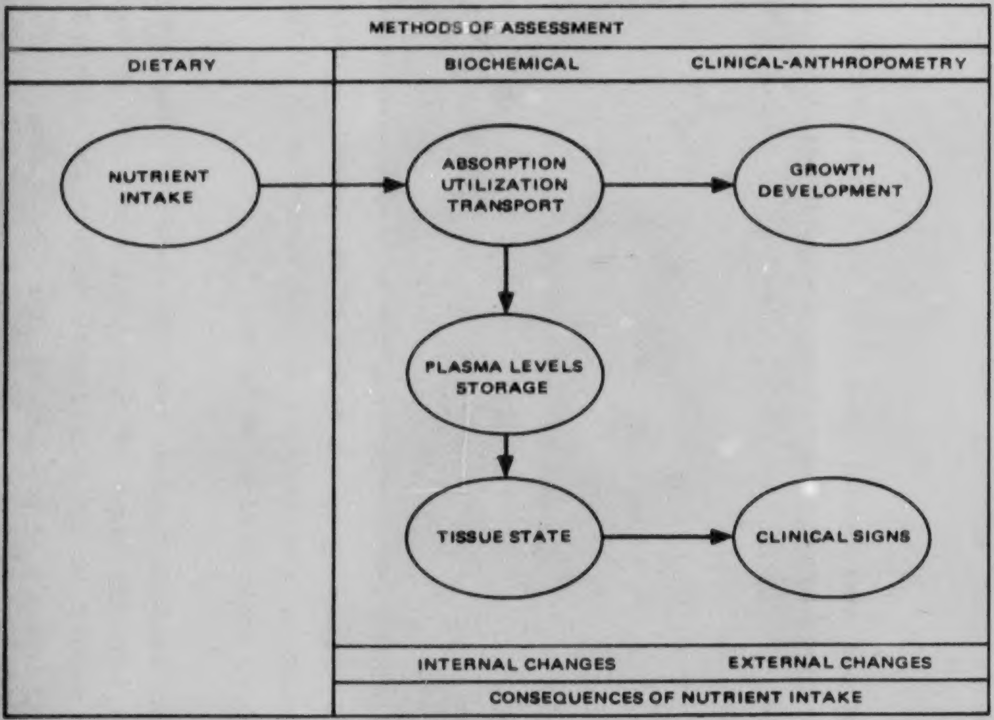
METHODS OF ASSESSMENT
DIETARY
BIOCHEMICAL
CLINICAL-ANTHROPOMETRY
NUTRIENT INTAKE
ABSORPTION UTILIZATION TRANSPORT
GROWTH DEVELOPMENT
PLASMA LEVELS STORAGE
TISSUE STATE
CLINICAL SIGNS
INTERNAL CHANGES
EXTERNAL CHANGES
CONSEQUENCES OF NUTRIENT INTAKE

Figure II-1. Interrelationships of the Four Methods for the Assessment of Nutritional Status

Biochemical methods evaluate the adequacy of dietary intake and the utilization of nutrients as reflected by their observed level and activities in the body. Some biochemical measurements refer to short-term dietary intakes, while others represent more long-term nutritional status. The standards used to interpret biochemical information are derived from the distribution of values in a "healthy" population and from studies designed to determine the levels that maintain healthy individuals free of clinical disease.

Anthropometric methods are usually classified as a subcategory of clinical methods, since both anthropometric and clinical methods look for physical signs and symptoms of malnutrition. Anthropometric methods typically assess the general effects of over- or undernutrition on growth and development. Clinical methods look at the appearance of such things as hair, eyes, skin, mouth, and nails to detect signs of specific nutrient deficiencies. Clinical methods also include examinations of dental status and the skeletal, muscular, and gastrointestinal systems. Heart rate, blood pressure, nervous reflexes, psychological stability, and other indicators of general health status can also be assessed (Christakis, 1973).

Anthropometric standards are derived from the distribution of characteristics in the population. Depending on the method of assessment, clinical standards are based on population distributions of the variables of interest or are inferred from what is considered to be "normal."

Anthropometric and clinical findings are indications of long-term nutritional status variations, but the signs of malnutrition may not be specific; that is, they may be related to non-nutritional factors and, therefore, may not correlate well with dietary or biochemical data (Christakis, 1973).

Because dietary, biochemical and clinical-anthropometric measures represent different dimensions of nutritional status, no single method can be used to

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determine the nutritional status of an individual. Combined data from all methods must be viewed in light of an individual's medical history, environment, and current health status before a diagnosis can be made.

Similarly, the prevalence of malnutrition in a population cannot be estimated from one set of measures alone and, although dietary, biochemical, and clinical-anthropometric measures are not completely independent, there is currently no way to combine them into a single "index of nutritional status" (Christakis, 1973). Furthermore, while some segments of the population may exhibit poor dietary intakes or low biochemical values, it is not possible to predict from these values what proportion of the population is likely to exhibit overt signs of malnutrition. For these reasons, dietary, biochemical, and clinical-anthropometric data from nutrition surveys are generally analyzed separately and attempts are seldom made to correlate one set of data with another. Consequently the various separate measures of nutritional status can only be used to indicate the degree of "risk" for malnutrition that exists in the population. The actual extent of malnutrition or the identity of individuals who exhibit it cannot be known unless additional data necessary to classify individuals are obtained.

Criteria for Selection of Measures

Several criteria can be used in selecting measures of nutritional status for large-scale surveys of school-age children. These include the following:

- The methods must be valid indicators of the nutritional status of individuals or groups, depending on the level of data analysis planned for the study.
- The methods should yield reliable data.
- Standards for the interpretation of data should be available.

- The procedures for collecting data must be feasible for large numbers of subjects under field conditions.
- The collection procedures must be acceptable to children, parents and school authorities so that a sufficient number of subjects will be willing to participate.
- The collection procedures and methods of analysis should be relatively inexpensive.

In the following sections of this chapter, these criteria are used to evaluate the various dietary, biochemical, and clinical-anthropometric methods of assessing nutritional status.

The usefulness of any measure of nutritional status--whether dietary, biochemical, or clinical-anthropometric--depends primarily upon its reliability and validity. Validity refers to the ability of the indicator to measure accurately what one is attempting to measure. A critical component of the validity of measures of nutritional status is their specificity--that is, the extent to which the measure is free of confounding influences that are not related to nutrition. In studies of impacts of nutrition intervention programs, an additional consideration for the validity of measures is their sensitivity--how well the measures are able to detect changes in the nutritional status of individuals or differences between population groups. Habicht et al. (1979) have pointed out:

> Sensitivity has different components depending on whether the indicator is used as a continuous variable to calculate means or to enumerate the proportion of malnourished persons in the population. The sensitivity of the population means is a composite of the sensitivity of the indicator in individuals. When the indicator is less sensitive to a given change in nutriture among better nourished than among poorer nourished individuals, it is clear that the sensitivity of an indicator in a population will be different depending on whether or not malnutrition in that population has a high or low prevalence. Measurement sensitivity also depends on the

> distribution of changes in nutriture within a population so that the same population's response to nutrition intervention may be quite different depending on how that intervention is distributed in the population (pp. 378-9).

These are important points for the selection of measures to assess impacts of programs, such as school lunches or breakfasts, which account for only a portion of the total food intake of participants. They suggest that the school nutrition programs cannot be expected to produce dramatic effects over relatively short periods of observation. Moreover, since few American children show signs of severe malnutrition, the likelihood of demonstrating program impacts will depend on the choice of measures that are most sensitive to modest changes or small differences in the prevalence of nutritional problems in a relatively well-nourished population.

"Reliability" is generally defined as the reproducibility of a measure. Good reliability is evidenced when the same results are obtained from repeated measurements on the same individuals. Reliability is a function of technical errors made in the process of measurement by the instruments, the investigators, or the subjects, and of the so-called "biological" or intraindividual variation--variation in the same individual over time that is not due to technical errors. According to Hegsted (1975), few attempts have been made to define the magnitude of these kinds of errors in estimates of nutritional status. Nevertheless, measurement errors and intraindividual variations can affect the selection of methods for determining impacts of school nutrition programs in several ways.

The more sources of measurement error that are introduced, the less confidence one can have that the values obtained represent a "true" result. If the values obtained from a nutritional status measurement cannot be considered absolute, it becomes impossible to classify individuals in relation to standards that use "cutoff points" to define nutritional problems, since there is a high probability that an individual will be misclassified. As a result of the inability to classify individuals accurately, it becomes difficult to estimate with confidence the proportion of the population at risk of malnutrition or the number who could potentially benefit from nutrition intervention programs. Evaluation of program impacts is limited to comparisons of the distribution of values among subgroups on the assumption that measurement errors are constant. The discovery of significant differences among subgroups does not necessarily indicate that the program has resulted in improved nutritional status, and may therefore have little practical meaning for public policy decisions.

Measurements that are subject to high degrees of intraindividual variation can further complicate the analysis of results. They will be impossible to use in analyses that attempt to determine program impacts on individuals unless baseline data are gathered prior to program participation. In group comparisons, a high degree of intraindividual variation on measurements will produce large standard deviations which may obscure real differences in nutritional status among the groups.

Nutritional status measures may be highly reliable and valid for determining impacts of nutrition intervention programs, but may be unsuitable for other reasons. The demand for generalizable results requires that studies of program impacts be conducted on a representative sample of the population. Methods that place heavy burdens on subjects for data collection or are otherwise unacceptable will affect cooperation and the rate of response. If large numbers of subjects produce unusable data or decline to participate, a biased sample will result.

The feasibility and cost of conducting large-scale field surveys must also be taken into account. Components of feasibility and cost include the availability of equipment, facilities, and materials for data collection and analysis, the level of expertise required of data collectors, and the time required for training, standardization, data collection, and analysis procedures. There are no absolute criteria for evaluating the feasibility and cost of methods of nutritional status assessment. Decisions regarding feasibility and cost are usually made from a trade-off analysis between the reliability and validity of various measurements in relation to ethical, environmental, and budgetary constraints.

Organization of the Chapter

The following sections of this chapter review the available literature on methods of nutritional status assessment. The unifying question throughout the review is:

WHAT METHODS HAVE BEEN USED TO ASSESS NUTRITIONAL STATUS OF SCHOOL CHILDREN, AND WHAT ARE THEIR STRENGTHS AND LIMITATIONS?

Dietary, biochemical, and clinical-anthropometric methods are discussed separately. The methods of data collection, analysis and interpretation that are commonly used for each of these parameters of nutritional status are described and the literature concerning validity, reliability, cooperation of subjects, feasibility, and cost is reviewed. Conclusions are drawn regarding the suitability of methods to assess the nutritional impacts of school nutrition programs.

The review emphasizes dietary and anthropometric methods of nutritional status assessment. The discussion of anthropometric methods focuses on measures of growth and development in children. Biochemical methods are reviewed in less detail. Anticipated problems of cooperation, feasibility and cost in large-scale surveys, together with the findings of previous research, suggest that biochemical measures are of limited value in studies of school nutrition programs in the United States. Readers who wish to obtain a more comprehensive evaluation of biochemical methods are referred to the textbook on Laboratory Tests for the Assessment of Nutritional Status by

Sauberlich et al., (1974). Methods that seek to discover clinical signs of disease caused by deficiencies of specific nutrients are not reviewed at all. Since these deficiencies have a very low prevalence among American school children, they offer little promise for the detection of impacts of school nutrition programs. A comprehensive review of clinical measures of dental health and the general health status of children is beyond the scope of this report.

A. *What Dietary Methods Have Been Used to Assess Nutritional Status and What Are Their Strengths and Limitations?*

OVERVIEW

Survey techniques that have been developed to assess dietary intake have been classified by Acheson et al. (1980) according to the means of data collection, as follows:

- Indirect determination of group consumption such as inspection of family food budgets, larder inventories, or agricultural production statistics;
- Direct measurement and recording of food as eaten by individuals;
- Recall by individuals of their past food consumption.

Of these three types of techniques, only those that take data directly from individuals are appropriate for a study of school nutrition program impacts. Indirect methods that aggregate data from groups do not allow data to be separated according to the participation status of individuals who comprise the group. Although indirect aggregate methods may be appropriate for studies of food waste in school nutrition programs, such studies are beyond the scope of this review.

The most common techniques for direct measurement and recording of food as eaten are the weighed food record and the estimated food record. Recall methods usually take one of three forms: (1) recall of food consumed during the past 24 hours, (2) diet history describing the subject's usual intake, and (3) food frequency questionnaire indicating how often items on a specified list are consumed.

Each of these dietary methods is potentially suitable for the assessment of school nutrition program impacts. The methods are described in the following sections, together with examples of protocols from large-scale studies that have used these methods to collect dietary data from school-age children. A review of literature follows, bearing on the cooperation of subjects, reliability, validity, feasibility, and cost of the various techniques. Additional discussions cover the interpretation of dietary data, including procedures for determining the nutrient content of food and the availability and use of dietary standards.

DESCRIPTION OF METHODS

Weighed Food Record

The weighed food record has been variously called the recipe method, the individual inventory and the precise weighing method (Pekkarinen, 1970). The principle of the method is that all food used at home is weighed prior to eating and food waste is weighed after the meal. The amount of food consumed is calculated by the difference between the amount prepared and the amount wasted. The amount consumed is immediately recorded, along with the name of the food and, where applicable, details such as brand, form of purchase (e.g., fresh, frozen, canned), and method of preparation. For combination dishes such as stews or casseroles, recipes are given that include amounts of ingredients used during preparation.

The weighed food record is kept for all food, beverages and snacks consumed during the survey period. When the method is referred to as the "precise" weighing method, the actual weighing of food is done by the investigators (Marr, 1971). Subjects can also be taught to weigh their own food. In this case, the method is called the recipe method or individual inventory. This form of the weighed food method is most commonly used in field surveys.

Although the weighed food method aims for a complete record of all food consumed, it is rarely possible for subjects to weigh all food eaten away from home. In most studies, subjects are asked to estimate the size of portions of food eaten away from home.

The number of days that foods are weighed directly affects the reliability and validity of results. This is discussed at length later in this section. In studies using weighed food records, periods vary from 1 to 28 consecutive days. For most studies, subjects are asked to keep records for one week. Some studies using the weighed food method have collected seven-day records at several periods during a given year.

Estimated Food Record

This method is sometimes called the "household measure" method (Burke & Pao, 1976). The method requires subjects to record foods eaten during the day but does not require them to weigh the foods on a scale. Instead, amounts are recorded in household measures such as cups, glasses, tablespoons and teaspoons. Foods that cannot be measured by volume (e.g., meat cuts, bread, pieces of cake) are expressed as common units (e.g., 1 slice) or are described according to size (e.g., cake 2 inches square). In most studies subjects are asked to actually measure the quantities of food served minus those left over, taking the difference as the amount consumed. Standard measuring cups, glasses, spoons and rulers are supplied to subjects for this purpose. In other studies, subjects use their own measures or estimate amounts consumed by merely "eyeballing" the portions.

As with the weighed food method, amounts of food consumed are listed on the estimated record as they are eaten. Details regarding form of purchase and preparation are also supplied. The various periods for data collection are similar to the weighed food record.

24-Hour Recall

The recall method requires subjects to state the kinds and/or amounts of food that they have consumed in the recent past. The recall period may be for two or more days, a week, or even two weeks or more, but the most common period is the 24 hours immediately prior to data collection (Pekkarinen, 1970). The recall method can also be used for portions of a day or a single meal.

Some studies call for a simple listing of menu items, but most studies ask for amounts as well as descriptions of the form and preparation of the food. In such cases, the kind of information sought is identical to that obtained from an estimated food record. The difference is that instead of measuring the food as eaten, the subject tries to remember what was consumed. The information can be obtained in several ways. The subject may be asked to write down what was eaten on a blank sheet of paper or he/she may be given a form divided by day intervals, with separate columns for recording amounts and descriptive details. Both of these methods can be self-administered without the aid of an investigator.

The most typical procedure is to obtain the recall by interview. The interview can be conducted in person or over the telephone. There is some controversy regarding the amount of prompting interviewers should give to subjects to aid their recall of what foods were consumed. Some investigators believe that too much prompting leads subjects to report foods they did not actually eat but think the interviewer expects. This has been called "talking a good diet" by Madden et al. (1976). Others believe that some prompting is necessary to prevent subjects from omitting foods they actually ate, but there is disagreement over the wording of the cues. Some investigators insist that culturally biased words like "breakfast," lunch," and "dinner" should not be used. Rather, cues should refer to the time of day (e.g., what did you eat in the morning?) or should be associated with activities (e.g., did you eat anything on your way to work or school?).

Similar controversies arise over what period should be covered by the 24-hour recall. Some investigators use the entire day preceding the interview beginning with the first thing subjects ate upon rising in the morning and ending with the last thing eaten at night. Others believe it is easier for subjects to recall items by working backwards. The recall begins with whatever was eaten immediately prior to the interview. Subjects are then led backwards in time so that the 24-hour period may actually include portions of two different days. The effects of these variations in format have never been subjects of systematic investigation. Further details on formats of 24-hour recalls used in major surveys and the modifications to them for collecting data from children are provided in the following section on dietary protocols.

While there is disagreement about how much prompting should be given to subjects to help them remember what foods were eaten, there is a general consensus that once a subject mentions a food, help should be given to recall the amount. In face-to-face interviews, questions to clarify quantities can be accompanied by a variety of visual aids. These may range in sophistication from simple household measures and cut-out pictures of food to more elaborate three-dimensional shapes or lifelike replicas. The various types of food models serve as reference points. The subject estimates portions of food actually eaten as less than, equal to, or greater than the

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models. This estimate is then coded as a proportion of the model weight, volume or size and is converted to gram weights or household measures.

Food Frequency

Methods that require subjects to recall or record actual consumption are limited in the scope of time that can be covered by the subject's memory or willingness to cooperate. The food frequency is one method that has been developed to obtain data that are characteristic of the usual diet over an extended period of time. It has been used most extensively in epidemiological studies requiring large samples of subjects (Marr, 1971). Data can be obtained by a self-administered questionnaire or by interview. There are many variations of the method, but the most common procedure is to present the subject with a list of foods and ask the subject how often each food is eaten. The subject may be asked to recall how often each food was actually eaten over a stated period of time (e.g., within the past year or past six months) or the subject may be asked for a more general indication of usual frequency that is not tied to a specific time span. Precoded categories of response are usually used. Some food frequencies are simple "often," "seldom," or "never" response categories. Others ask for the number of times the food is eaten per month, per week, or per day.

In addition to frequency of consumption, the amount of each food that is typically consumed has also been obtained with the food frequency method in some studies (e.g., Abrahamson et al., 1963). In such studies, average portion sizes (as opposed to actual amounts) are estimated. Subjects can be assisted in the estimating process with household measures and food models.

There is no standardized list of foods that appears on all food frequency lists. Indeed, one of the advantages given for the method is that the list of foods can be tailored to the interests of each study (Abrahamson et al., 1963). If dietary patterns rather than total nutrient intake are of interest, the list may consist of selected food items believed to be characteristic of different patterns or it may focus on specific items high in dietary constituents thought to be associated with disease (Wiehl & Reed, 1960).

Diet History

The diet history is another interview method developed to provide data that are characteristic of the usual diet. The method, as originally developed by Burke (1947), was intended to be used in research that compares the average food intake of an essential nutrient or average level of the diet as a whole with clinical and laboratory findings. The method follows four basic steps. First, background data on the subject's health status and other factors that relate to nutrition (such as living arrangements, economic status and eating habits) are obtained. Next, the nutritionist attempts to learn the subject's usual pattern of eating at meal times and between meals. This portion of the interview follows a format similar to a 24-hour recall except that the subject is asked about food intake on a typical day rather than an actual day. Further questions are asked to obtain details about variations from the usual pattern. For example, in discussing breakfast, the subject may state that he/she usually has orange juice three or four times per week and on other days may have no fruit, or will substitute tomato juice. Similar detail is obtained about other parts of the meal and other periods of the day. The frequency and usual portion sizes of all foods are recorded along with any changes in the usual pattern that occur because of special circumstances, such as illnesses or holidays.

The third step in the history is called the "cross-check." According to Burke, this step is very important in clarifying and verifying the information given as the usual intake. The interviewer works from a list of food groups, asking the subject questions about likes, dislikes and the consumption of foods in each group. Answers are compared with the usual intake and discrepancies are discussed. In the final step of data collection the subject keeps an estimated food record for three consecutive days following the interview. Experience with the record led Burke to conclude that the record was the least valuable portion of the diet history method and should be used only as an additional check on the usual intake for a given interval. Her reasons were that a high number of inaccuracies and omissions were discovered in the records.

The method of data analysis was an integral part of the diet history method as originally developed by Burke. From a consideration of the usual intake and the cross-check, the amounts of each food or food group which are most representative of the subject's average intake are selected. The nutrients from this average intake are then calculated. Because Burke believed that these figures would give an unjustified impression of accuracy she used them only in conjunction with a rating scale which was based on the Recommended Dietary Allowances. Each nutrient was rated "excellent," "good," "fair," "poor" or "very poor," according to the range in which the value calculated from the average intake fell in relation to the RDA. Burke thought that the ranges were sufficiently wide to absorb the inaccuracies of the history method and could serve to place a subject in the correct relative position to other subjects for a specific nutrient.

Other researchers have made numerous modifications to this method. For example, Beal (1967) used all of the components described by Burke in longitudinal studies of the growth and development of children, but treated the nutrient values as absolute and did not use the rating scale. Reshef et al. (1972) used a "Burke-type" interview consisting only of the portion eliciting usual intake and cross-check information. Mann (1962) obtained dietary data for the Framingham study of risk factors in cardiovascular disease using the diet history method. In that study subjects were given advance notice that they would be questioned and the interview on usual intake was unstructured. The method included both the preliminary history and the cross-check but omitted the rating scale.

PROTOCOLS FOR DIETARY ASSESSMENT

Protocols are the actual questionnaires, data forms and instructions to data collectors that are used in dietary surveys. Protocols differ in content and format according to the dietary data collection methods that are used. Every study that collects dietary data must select or develop protocols and standardize them prior to field use. During the survey, it is also necessary to maintain adequate quality control. These factors contribute to the reliability and validity of the measurements.

Dietary protocols must be adapted for use in large-scale surveys and in surveys involving children. Protocols used in the Health and Nutrition Examination Survey (HANES) have been described by Youland and Engle (1976). This survey included the collection of dietary data from a probability sample of non-institutionalized persons in the United States aged 1 to 74 years. Frank et al. (1977) have described protocols used in the Bogalusa Heart Study. This study is targeted exclusively at children. Review of the dietary protocols used in these two studies provides additional understanding of the methods and helps identify factors that should be considered when collecting dietary data from large numbers of school-age children.

A study of school nutrition programs conducted in Washington State (Price et al., 1975) also contains a description of dietary protocols. The details are described in Chapter IV in conjunction with a critique of the methods used in that study.

Health and Nutrition Examination Survey

The Health and Nutrition Examination Survey (HANES) used a 24-hour recall and a food frequency questionnaire as the means of collecting dietary data from a national probability sample that included over 5,000 school-age children. A maximum of 30 minutes per subject was allowed for the entire dietary interview. The 24-hour recall portion of the interview was conducted first. It covered midnight-to-midnight of the whole day prior to the data collection day. Data were collected for weekdays only.

The interviewers used a variety of techniques to help subjects recall the amounts of foods consumed. These included food models and measuring devices. Probes were also used to uncover forgotten snack items. People were often able to associate foods with specific activities. Interviewers became familiar with local foods and brand names sold in neighborhood grocery stores to help subjects identify specific items. Translators were used for non-English-speaking subjects.

The food-frequency form contained 13 broad food categories: milk, meat and poultry, fish or shellfish, eggs, cheese and cheese dishes, dry beans and peas, fruits and vegetables, bread, butter and margarine, desserts and sweets, candy, beverages and snack foods. Two to three subcategories each were provided for milk, fruits and vegetables, bread (including cereals) and beverages so that a total of 19 items were assessed. Subjects were asked to indicate the number of times per day or week each item was consumed over the past three months.

In addition to providing data describing general food patterns, the food frequency was used as a cross-check on the 24-hour recall. For example, if a subject reported eating bread three times a day on the food frequency but only once on the 24-hour recall, the interviewer would question the subject about the discrepancy.

Children aged eight and over provided data to interviewers unassisted. Younger children were interviewed with their parents or another responsible adult. It was observed that many mothers of young children turned the interview over to their children, stating that they paid little attention to what their children ate.

The same food models and probes were used with children as with adults. To help children remember what was eaten for school lunch, a tray or plate was drawn on a piece of paper and the child was asked what was placed in various positions. If the child could remember the color but not the name of a food, a call was made to the school to learn what had been served. Youland and Engle do not report whether modifications were made in the food frequency questionnaires administered to young children.

All dietary forms used by the HANES interviewers were coded in the field. The recording form for the 24-hour recall allowed interviewers to record amounts of food consumed according to letter codes corresponding to the food models. A loose-leaf notebook contained identification numbers for specific food items based on Agricultural Handbook No. 8 and other nutrient data sources.

All dietary data were processed by computer. The data base for the nutrient composition of foods was adapted from one originally created at Tulane University and used in the Ten State Survey (Center for Disease Control, 1972); however, to accommodate new products and/or changes in nutrient composition, more than 200 additions or changes in the data base were made during the entire HANES operation.

Quality control was an important aspect of HANES. Quality control procedures for the dietary portion of HANES consisted of training sessions, evaluations of interviewing and coding skills, and feedback concerning performance.

Each interviewer received at least one week of training, which included practice interviewing and recording. During the orientation and data-collection phases of the survey, written guidelines were used that gave instructions for the type of information to be obtained, for maintaining a log of all persons interviewed, for the use of food models, and for conducting the interviews. The guidelines also contained detailed explanations of the forms and instructions for transmitting information to headquarters.

During the data-collection phase, two randomly selected interviews were tape recorded by each interviewer and later evaluated by headquarters staff. Written evaluations were sent back to the interviewers. Two meetings were also held with all of the interviewers during the survey to pool ideas and discuss problems. A midpoint quality control test designed to check coding skills consisted of a 24-hour recall form containing a series of interview questions together with subjects' responses. Each interviewer coded the responses and returned the form. The test enabled the survey directors to determine the error rate and the most common types of problems in coding.

Bogalusa Heart Study

Frank et al. (1977) have described the detailed protocol used for obtaining 24-hour recalls, calculating school lunch data, and developing interview techniques used in the Bogalusa Heart Study. This study is being conducted by the Special Center for Research on Arteriosclerosis at Louisiana State University Medical Center. One objective of the study is to develop methods that will assess and characterize the dietary intake of children, allowing the children to respond independently. The protocol is used with children who are ten years old and older.

The 24-hour recall reflects hour-by-hour consumption beginning with food and beverages consumed on the day of the interview and ending with food consumed on the day before to complete the 24-hour period. The interviewer follows a written script of questions. Examples of questions from the script are:

- What's the first thing you ate or drank after you got up this morning?
- When did you next eat or drink something?
- Do you have recess in the morning? Did you eat anything then?
- Were any of your favorite TV shows on last night? Did you have a sucker, popcorn, doughnut, cookie, or soft drink while you watched TV?

Eating locations or situations are also mentioned to help the child remember foods associated with various occasions; for example:

- How do you get home from school? Did you buy anything before you got on the bus?
- Did you go to a meeting, football game or party last night? Did they serve refreshments?

As children name each food they are shown food models and product labels to identify quantities and brands. The food models, developed by Moore et al. (1967), do not depict specific foods but, rather, show various portion sizes, weights, volumes and shapes.

Experience in interviewing has shown that children are likely to forget to report eating snack items. The interviewers probe for snack items using a "Product Identification Notebook" that contains pictures of snack foods, labels and drawings. At the close of the interview, the book is reviewed page-by-page with the child. Finally, each child is asked a series of questions regarding sleeping habits, typical eating patterns and the use of salt.

The exact contents of school lunches are also determined on the day of the 24-hour recall. The nutritionist visits the cafeteria to obtain recipes and to weigh foods as served. Three samples of each food are weighed and the average weight is recorded in grams on a standardized form. Knowledge of types and amounts of foods served in school lunch is used during the 24-hour recall with children to obtain a more accurate estimate of what was consumed.

The protocol contains detailed instructions for recording data obtained from the 24-hour recall. Specifically, each food listed by the child is accompanied by the following information: common name and/or brand, method of preparation, the form of purchase, and the portion size in food-model units. These units are converted to gram weight equivalents by the nutritionist. Each food is also assigned an ID number and is coded for the time it was eaten during the day. If a food is unfamiliar or is a combination food made from a home recipe, research is done following the interview to obtain a list of ingredients. The ingredients and amounts are noted on the recall form and are also recorded in a "Product Research Notebook" for future reference.

Quality control procedures in the Bogalusa study consisted of checking all food identification numbers, equivalent conversions, gram weight calculations and other codings by a second nutritionist. Differences that could not be immediately resolved become subjects of a staff conference. When all errors were corrected the data forms were submitted for computer processing using the Extended Table of Nutrient Values (Moore et al., 1974).

Cooperation of Subjects

For any nutritional assessment method it is important to identify factors affecting the cooperation of subjects, but these factors are especially critical in the selection of dietary measures. Biochemical and clinical-anthropometric measures are essentially non-reactive, but most dietary measures suitable for determining nutrition program impacts depend upon the subject's ability and willingness to provide accurate and truthful information. Special problems are encountered when the subjects of a dietary investigation are children. Furthermore, some dietary methods place a heavy burden on respondents for data collection. All of these factors add to the potential for unreliable data or sample bias due to nonresponse.

Marr (1971) conducted a systematic analysis of cooperation rates for various dietary assessment methods reported in earlier studies. Components of non-cooperation included the percentage in the samples who were unable to cooperate, who produced "doubtful" or incomplete data, or who refused to participate. The samples in the studies that Marr reviewed were composed of a variety of age, sex and occupational groups. Children were the subjects in several of the studies, but in most of these studies, the mothers rather than the children were the respondents.

Food Records. According to Marr (1971), the precise weighing method, in which investigators perform the weighings, can only be used by highly cooperative, motivated subjects who are willing to allow the investigation to intrude into their daily lives. The method cannot be carried out on a random sample, since the degree of cooperation required is likely to deter participation. Marr states that the weighed food record, in which the subjects weigh their own food, has wider application. Six studies using seven-day weighed food records were reviewed by Marr. All were carried out in Britain. Cooperation rates (i.e., the percentage of usable or "reliable" records obtained from the sample) ranged from 32 percent in a study of 72 elderly women in Paisley, England, to 79 percent in a study of 231 London busmen. The largest components of non-cooperation in all of the studies were the numbers who were unable to cooperate and the numbers who refused to participate.

Since cooperation can potentially be a problem in surveys using weighed food records, it is important to determine how high rates of non-response are likely to bias the sample. In the studies reviewed by Marr involving children, fewer records were obtained for households with low incomes and from mothers with low educations.

According to Marr's analysis, use of estimated food records does not necessarily improve cooperation rates over those obtained with weighed records. Four studies using estimated food records from child and adult subjects were reviewed. The lowest percentage of usable records in all of the studies--45 percent--came from a sample of 150 adolescents studied by Sprauve and Dodds (1965). The authors stated that the poor response "rendered the sample less representative than was desired and certain correlations could not be established." This study suggests that adolescents may not be willing to cooperate in studies using food records.

Gersovitz et al. (1978) also report problems of nonresponse with estimated food records. Dropouts occurred in such a way that as the days progressed, subjects completing records tended to be better educated than the group as a whole. Although subjects in this study were elderly persons, similar patterns of dropout could be expected from mothers and children.

The findings of some studies suggest that shortening the time period required for data collection can increase levels of cooperation with the estimated food record. Dierks and Morse (1965) asked mothers to keep three-day estimated records for 121 preschool children in Minnesota. The cooperation rate in that study was 95 percent. However, decreasing the number of days allowed for estimating food intake has implications for reliability and validity of the data. These implications are discussed at length in later sections of this review.

There is no good evidence in the literature about the age at which children are able to keep weighed or estimated food records without the assistance of adults. The minimum requirements are that the child must be able to write the names of foods and take accurate measurements with household measures or scales. The mathematical operations of addition, subtraction, multiplication and division--as well as the concept of fractions--must also be understood. Young et al. (1951) considered children below the fifth grade (i.e., under ten years of age) too young to keep seven-day food records. In their study of 350 children in New York, Young et al. allowed children ten years old and older to keep their own estimated records, but requested help from parents and teachers for children aged four to nine. Other studies using food records with children (e.g., Huenemann & Turner, 1942; Bransby et al., 1948; and Trulson, 1954) do not indicate at what age children were asked to keep their own food records. The results of Sprauve and Dobbs (1965) suggest that difficulties can be encountered with adolescents as well as with younger children.

Recall Methods. Methods that require subjects to recall past or usual food intakes--24-hour recall, food frequency and diet history--place less of a burden on respondents for data collection than methods that require them to weigh or record food quantities as eaten. Therefore, it is generally assumed that these methods pose less of a problem in obtaining the cooperation of subjects and can be used successfuly in probability samples of the population (Burke & Pao, 1976). It is difficult to evaluate this assertion from large-scale surveys because the dietary interview is usually only one portion of the total data collection effort. For example, the nonresponse rate for the dietary portion of HANES, which consisted of both the 24-hour recall and food frequency interview, was 27 percent (Burke & Pao, 1976). However, since the dietary interview was conducted in a mobile clinic at the same time that biochemical and anthropometric data were obtained, it is difficult to separate nonresponse on the dietary interview from unwillingness to participate in the biochemical and anthropometric examinations.

According to Marr (1971), in the reports of studies using recall methods, there is little information regarding the numbers of subjects who were unable to give data or who refused to do so. No comparisons of cooperation rates are made by Marr for studies using the 24-hour recall or food-frequency methods. Cooperation rates in four studies using diet histories are summarized by Marr. None of the studies involved children. Usable diet histories ranged from a low of 64 percent from industrial workers in Chicago (Paul et al., 1963) to 94 percent from state workers in New York (Browe et al., 1966).

Most authorities agree that the primary problem with recall methods lies in the ability of subjects to remember what they ate (Young & Trulson, 1960; Pekkarinen, 1970; Marr, 1971; Burke & Pao, 1976; Keys, 1979). Since this issue bears directly upon the validity of results, studies that have evaluated the accuracy of recall methods will be discussed more fully in the following sections. At this point, however, it is of interest to note some authors' comments about the cooperation obtained in studies using recall methods in which the subjects were children. For example, Bosley (1947) said that "children nine to eleven years old are easily able to recall the foods eaten over a 24-hour period and delight in measuring the quantity of food eaten." Bosley added that once children have reached 11 years of age, they "have acquired enough information about the foods they should eat to influence their reports."

More recently Frank et al. (1977) have stated that "children 10 to 12 years old were eager to talk about what they had eaten. The children established rapport quickly and usually remembered brand names of foods they had eaten. They seemed to remember eating times logically and clearly. When asked to recall a known school lunch, they were quite aware of their meals, but remembered the menu items in much simpler terms than those used by the school personnel" (p. 30).

The literature does not relate experiences of investigators who have tried to obtain 24-hour recalls directly from children younger than nine or ten years of age, nor could comments be found from investigators who have used the food-frequency method with children of any age.

The most extensive use of the diet history method with children is reported by Beal (1967). She used diet histories to collect dietary data on children who were part of a longitudinal study of growth and development in Denver. Beal states that the age at which a child is capable of giving a diet history is best judged on an individual basis. Prerequisites are an adequately developed sense of time, knowledge of the names of foods, a sufficiently long attention span, good memory and a willingness to cooperate. In Beal's experience, no data can be obtained directly from children below five years of age, but from the age of five or six years on, children can be asked about foods eaten away from home, such as the kinds and amounts of foods served in school lunch, which foods they eat or refuse, extra servings and foods exchanged with friends. However, children of this age must still rely on their parents for assistance to complete the history. Beal maintains that unaided histories should not be attempted until girls are at least 12 and boys are 13 to 14 years of age. With these children it is necessary to give assurance that the information is confidential and will not be reported to their parents; otherwise they will be reluctant to "tell how much candy they buy on the way home from school or whether they buy lunch at the corner drug store instead of the school cafeteria." Beal also says that children must be constantly reminded that there are seven days in a week, not just the five school days.

Discussion

Cooperation of subjects is an important issue in the selection of dietary methods. High rates of noncooperation have been discovered among various groups of subjects in studies using both weighed and estimated food records (Marr, 1971). Poor cooperation tends to bias the sample so that persons with low income and low education may be underrepresented (Marr, 1971; Gersovitz, 1978). None of the studies using weighed or estimated food records are based on a probability sample of subjects, and only a few studies obtained data from children. There is no evidence in the literature that food records can be kept successfully by children under ten years of age. Doubts are also raised about the extent to which older children are willing to cooperate with the requirements for weighing or estimating food intake (Sprauve & Dodds, 1965).

Methods that rely on recall of past or usual food intake offer fewer problems of cooperation. Response rates are reportedly high (Burke & Pao, 1976), but this has been difficult to verify in dietary surveys using national samples. Investigators that have used 24-hour recalls with children report that most children who are at least nine to ten years of age are willing to cooperate, but older children may not always provide truthful information (Bosley, 1947; Frank et al., 1977). Similar conclusions can be drawn about the use of the diet history method with children (Beal, 1967). There are no indications of how well children cooperate with the food frequency technique.

RELIABILITY AND VALIDITY

The following section presents a review of literature on the reliability and validity of dietary assessments. According to Young and Trulson (1960), problems of the reliability and validity of dietary assessment are generally approached from three different perspectives:

- Identification of the accuracy of dietary intake;
- Determination of the length of time to be covered by a dietary study;
- Comparison of results obtained by various dietary methods.

The first of these perspectives concerns identification of various types of measurement errors. Errors made by subjects due to poor cooperation affect the reliability of the data. Unreliable data can also result from errors in the use of instruments, such as scales or measuring cups, in determining the amount of food consumed, or from differences in the way interviewers collect or code data. An additional measurement problem that affects the validity of the data involves systematic errors that occur because subjects cannot estimate their food consumption accurately or because they change their eating habits while participating in the studies.

The length of time to be covered by the dietary survey depends upon how well the period of observation represents the dietary constituents that one is attempting to measure. This issue is related to the degree of variability in the dietary intake of individuals and of the general population. If dietary intake is highly variable from day to day, it will be difficult to obtain reliable estimates of nutrient intake over relatively short periods of time.

The third perspective, comparing one method to another, seeks to establish concurrent validity. Most authorities believe that the weighed food record is the most valid criterion (Keys, 1979; Marr, 1971; Pekkarinen, 1970); however, this method itself is subject to limitations. Furthermore, not all studies use the weighed food record as the basis of comparison. Consequently, the comparisons do not indicate which method is "best." They only show how results obtained by the various methods differ from one another and which can be used interchangeably to accomplish a specified purpose (Pekkarinen, 1970).

Accuracy of Dietary Intake Methods

In all dietary studies it is difficult to separate "true" variations in intake from variations due to different types of measurement error. Each assessment method is subject to its own measurement problems.

Weighed Food Record. It is generally recognized that use of the weighed food record has the potential for causing subjects to alter their food behavior during the period of observation. Burke and Pao (1976) point out that larger food intakes in the first week than in subsequent weeks are often reported in small-scale, non-random studies using weighed food records. They believe that this finding indicates either that behavior is altered by participation or that weighing becomes more careless as time goes by. Burke and Pao cite studies by Yudkin (1951) and Ohlson et al. (1950) to support this possibility. In the latter study, which gathered weighed-record data from 13 women, snack items were seldom listed. The authors suggest that snacking may have become inconvenient for the women when it was necessary to weigh each food. Burke and Pao also quote den Hartog et al. (1965), who noted that subjects admitted changing food behavior by serving simpler meals with fewer variations in order to lessen the work.

Estimated Food Record. Huenemann and Turner (1942) reported that they had initially planned to use estimated records in their study; they discarded this technique in favor of weighed records when it was discovered that considerable measurement error would be encountered. They observed that measuring cups could be loosely or tightly packed, and such foods as pastry, raw fruits and meat did not conform to measuring devices. Moreover, subjects frequently substituted estimates (i.e., "eyeballing") for actual measurements.

Marr (1971) reviewed literature on similar problems of standardizing measures used for estimated food records. In one experiment (Lockwood et al., 1968), two observers used different sized teaspoons, dessert spoons and tablespoons to measure 27 different foods. Both "level" and "heaped" spoonfuls were compared. Large variations in measurements occurred; for example, in weighing one type of sugar, one observer obtained a mean of 1.8 g for ten measurements while the other obtained a mean of 4.0 g, a difference of over 100 percent. According to Young et al. (1952), "errors in estimation of portion size are probably the largest source of error in diet record keeping."

In studies of the dietary intake of children, there are special concerns about whether children can make accurate measurements. Young et al. (1952) obtained data using estimated food records in studies conducted in six different states. The samples from the different states consisted of different types of subjects--two of the six samples were of school-age children from Maine and New York. Methods of data collection also varied, but the basic comparison was between nutrient values obtained from meals when subjects estimated their own food intake and values obtained when the portions and waste were measured by someone else.

When mean intakes estimated by the groups for calories and nine nutrients were compared with measured mean intakes, the values were not significantly different for any of the samples except the group of school children from New York. Mean values obtained by the children for all nutrients except vitamin A and calories exceeded the measured values obtained by adult observers by more than 20 percent. The authors note that these children were unaware that they were being observed. In contrast, children in the sample from Maine did know that an experiment was taking place. In this case, agreement between their estimates and those obtained by the observers was very close. Young et al. state that it is impossible to know how much the awareness factor could have affected the results. The findings suggest that children make more accurate measurements when they are prepared for the study.

Young et al. also determined the proportion of individuals in each sample whose estimates came within 20 percent of the measurements obtained by the observers for each nutrient. Overall, the two samples containing children were at opposite ends of the spectrum. In New York the average percentage of individuals who came within 20 percent for all nutrients was 19 percent. The worst estimates were for calories, iron and thiamin. In Maine an average of 25 percent of the children came within 20 percent of the measured values. In all samples, greater variations between estimates by subjects and measures by observers were found on an individual basis than in the group comparisons.

24-Hour Recall. Critical factors in the accuracy of all recall methods are the biases introduced by the interviewers and the extent to which subjects can remember the kinds and amounts of foods they have eaten. Ability to recall accurate amounts is, in part, dependent upon the kinds of probes and visual aids used during the interviews.

Two studies have examined the effects of different interviewers on sources of measurement error in the 24-hour recall (Frank et al., 1977; Beaton et al., 1979). The use of probing questions to aid recall of foods consumed has also been studied (Campbell & Dobbs, 1967).

The protocol for the 24-hour recall used by Frank et al. in the Bogalusa Heart Study was described in a previous section. This protocol was pilot tested on 76 boys and girls aged 10 to 16 years in Franklinton, Louisiana. The children were randomly selected and scheduled for an interview between Tuesday and Friday. Ten of these 76 children were re-interviewed about the same 24-hour period by a second nutritionist. Half of the children had their first recall taken by one nutritionist and half had their first recall taken by the second nutritionist. A third nutritionist checked the duplicate recalls before analysis. There was no significant difference ($p < .05$) between interviewers for the mean intakes of calories, percentage of calories from fat, percentage of calories from protein, total cholesterol, polyunsaturated-to-saturated fat ratio, and sucrose-to-starch ratio. Coefficients of variation ranged from 9.5 for the percentage of calories from protein to 27.3 for cholesterol. All coefficients were below 20 except cholesterol and the sucrose-to-starch ratio (20.9). The authors conclude that the 24-hour recall has an acceptable level of reliability when standard protocols are used with children.

The study by Beaton et al. also looked at measurement errors in the estimates of intake. These investigators examined the variation contributed by interviewer effects, sex of the subject, day of the week the diet is studied, and the training of subjects due to repeated interviews (i.e., sequence effects). Thirty male and 30 female adult subjects were each interviewed six times-- twice by each of three nutritionists and twice on each of three days of the week. The dietary components studied were calories, protein, carbohydrate, fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids and cholesterol.

The results showed that for all dietary constituents, the major components-of-variance were between subjects (i.e., interindividual variation) and the unfactored residual (i.e., intraindividual variation). In order to minimize the variance due to different interviewers and to sequence effects, a defined protocol was used by trained interviewers. Neither of these sources of variance was significant in any of the analyses. Day-of-the-week exhibited a small but significant effect on the diets of female subjects. Females tended to consume more food on Sundays than on weekdays. The contribution of day-of-the-week to total variance ranged from 3.2 percent for polyunsaturated fatty acids to 9.4 percent for calories. However, when nutrient constituents were expressed as concentrations (i.e., nutrients per 1000 calories), the day-of-the-week effects for females disappeared. There was no significant day-of-the-week effect for males in either absolute intakes or concentrations of the various dietary constituents.

The use of probes to improve accuracy of the 24-hour recall was investigated by Campbell and Dodds (1967). Data were collected from 300 young adult and elderly institutionalized subjects and from 100 elderly subjects living at home. Menus actually served to the institutionalized patients were known by observation. This enabled the investigators to develop specific questions regarding the kinds and quantities of foods eaten during the 24-hour period. For the institutionalized older subjects, 35 and 28 percent of the energy intake calculated from the 24-hour recalls of men and women, respectively, was due to probing, using the known menu as a reference. For the younger institutionalized patients, 12 percent of the calories for women and 21 percent of the calories for men were obtained with the probes. Older persons living at home could recall more of their intake than the institutionalized subjects. For this group, probing uncovered 18 percent of the total calories reported by men and 12 percent of the calories reported by women. For all subjects in institutions, carbohydrate, vitamin A and ascorbic acid values of the diet increased most as the result of probing. For the persons living at home, probing resulted in the greatest increases for calcium and saturated fat.

No comparable studies of the use of probes with chidren have been made, but three investigators have looked at how well children can recall what they have eaten (Bransby et al., 1948; Meredith et al., 1951; Emmons & Hayes, 1973).

Bransby et al. studied the dietary intake of 50 children aged 10 to 15 years living in an institution in England. Foods served to the children and left over on their plates were weighed for three consecutive days. Average intakes for the three days were computed for calories, carbohydrate, fat, protein, calcium and iron. Each evening, children were questioned about the amounts and quantities of food consumed during the previous 24 hours. Only small differences were found between the average daily amounts of food obtained by weighing and the average daily amounts obtained by questioning the child. The largest differences were for sugar, preserves and fats. Differences in nutrients calculated from the weighed versus the questioning methods were not large. The greatest difference was for calcium, where questioning underestimated average weighed intake by 5 percent. In discussing these results the authors state that it is unlikely that the questioning method received a satisfactory test, since children in the study "took a lively interest in the proceedings and familiarized themselves with their food more than is usual."

Meredith et al. studied 94 children (48 boys and 46 girls), aged 9 to 18 years, in Maryland. A record of actual consumption and a recall for one school lunch was obtained for each child. To obtain actual consumption data, a nutritionist weighed and measured portions of food during preparation and recorded all ingredients. Amounts of foods served to children in the study were recorded on a card coded with each child's name. After children had finished the meal they were instructed to return their trays to the "turn-in window" where quantities of all uneaten food were recorded on the card. The authors do not state whether these leftovers were estimated or weighed.

Soon after lunch, the children were interviewed individually to obtain the recalls. The interviews were conducted by a second nutritionist who had no knowledge of what had been served. Questions were asked about food eaten that was not part of the school lunch and about items given away. The authors do not state whether food models or other visual aids were used.

Data were analyzed by comparing the number and quantity of food items from the computed record with those recalled by the child. The criterion for agreement was very literal and did not allow any latitude for slight differences between the child's recall of quantities and the standard portion sizes. The recalled and computed records agreed completely in number, kind, and quantity in only six of the 94 comparisons. In 33 comparisons (35 percent), children gave the same number of items and kinds of foods as appeared on the computed record, but there was a difference in quantity for one to three items. In the remaining 55 comparisons (58 percent) there was a difference in the number and type of items as well as in quantities. There appeared to be a tendency for greater underreporting as the number of different items on the tray increased. Also, the authors noted that there was better agreement on the third day of the study. The authors think that children taking part in the study may have discussed it with other children, so that by the third day they were better prepared for the interview.

Emmons and Hayes also tested the ability of children to recall school lunch by comparing recalls with a computed record. In addition, these investigators compared childrens' recalls of their 24-hour intake with recalls provided by their mothers. The subjects were from grades 1 to 4 (ages 6 to 12) in two rural upstate New York school districts. Twenty-four-hour recalls for the previous day were obtained from a total of 431 children at school. Household measures were supplied to help children estimate quantities of food. Mothers were interviewed by telephone to obtain recalls of their childrens' diets for the same 24 hours recalled by the children. Methods similar to those used by Meredith et al. were used by Emmons and Hayes to determine actual consumption of the school lunch.

In comparing recalls from mother and child, the investigators found that the majority of mothers listed each of 25 different food groups the same number of times as their children. When there was disagreement, mothers reported a smaller number of servings 10 percent of the time and a larger number of servings about 17 percent of the time. Food groups for which there was disagreement most often were milk, fruits, desserts and sweets.

When the child's recall of school lunch was compared with the computed record, it was found that the ability to recall correctly the kinds of food eaten improved with age. Children in grade 4 remembered an average of 80.6 percent of the food items in their school lunches, while children in grade 1 remembered an average of only 60.5 percent of the food items.

Comparisons of the quantities of foods obtained by the different methods were not made, but data from both mothers and children were converted into values for calories and eight nutrients. Correlation coefficients were calculated between nutrient levels in mother-child recalls and between recalled and recorded school lunches. In both types of comparisons there were fewer significant correlations ($p < .05$) in grades 1 and 2 (15 significant correlations) than in grades 3 and 4 (27 significant correlations). The magnitude of most correlations that were significant also tended to be lower for the younger children. In all age groups, there were more significant correlations between the nutrient levels from the child's recall of the lunch and the record of what was actually eaten (25 significant correlations) than between the nutrient levels from the mother's recall and the child's (15 significant correlations). This tendency increased with age. At grade 4, calories and all eight nutrients in the recalled lunch and recorded lunch correlated at the .01 level. The range of coefficients was from .58 for ascorbic acid to .92 for calcium. At the same grade, only six of the nutrient correlations were significant between the child's and the mother's 24-hour recalls. The range for all nutrients was from .11 for vitamin A to .62 for riboflavin. The nonsignificant correlations were for iron, vitamin A, and ascorbic acid. As the authors point out, these results do not necessarily mean that the child's recall is more valid than the mother's, since no absolute record of what the child ate at home was obtained. Nevertheless, the agreement found on measures of intake at school lunch encouraged the authors to conclude that "young children, especially above grade 2, can give comprehensive dietary information."

Food Frequency. The accuracy of the food frequency method has not been evaluated as extensively as the accuracy of 24-hour recalls. There is one study by Abrahamson et al. (1963) that determined whether the frequency of intake of selected food items is an accurate representation of the quantities of these foods as they are usually consumed. The subjects were 60 pregnant women aged 17 to 39, receiving prenatal care from two community clinics in Israel. The women were all Jewish, but were heterogeneous in terms of country of origin. Each subject was questioned by the same interviewer about consumption of 26 different food items grouped into categories of milk, eggs, flesh foods, bread and rolls, and fruits and vegetables. Frequency was recorded as the number of times the food was eaten per week and the number of days it was eaten per week. The usual weekly quantities of each food were

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assessed using household measures and samples of food. Amounts were recorded in metric units for volume and weight.

Data for the total sample showed highly significant correlations between the number of times food items were reported as eaten per week and the usual quantity consumed. These data, however, were inflated by the women who said they never ate an item and therefore had a zero quantity of intakes. When the women who reported never eating an item were excluded from the analysis, correlations were still highly significant ($\underline{p} < .0001$) for all of the foods studied. The highest correlations were for eggs (.95), fruit and vegetable juice (.90), and milk taken as a beverage (.81). The lowest correlations were for poultry (.40), bread and rolls (.42), citrus fruits (.38), and certain vegetables (e.g., green beans .39).

Lower correlations between frequency and quantity were discovered when the number of days per week rather than the number of times per week that foods were eaten was assessed. Also, the correlations were lower when food groups were used rather than separate items. For example the correlation for the combined fruit and vegetable group was .38; for the combined group of flesh foods (poultry, meat and fish) it was .48. In spite of these relatively low correlations, it was possible to divide the 60 subjects into three subcategories indicative of low, intermediate and high frequency of intake for each food group and to obtain significant differences in the mean weekly quantities consumed.

Diet History. Dawber et al. (1962) studied interviewer effects on the diet-history method. Twenty-four subjects were interviewed two years apart by two different nutritionists using identical protocols. A different group of 30 subjects was also interviewed two years apart but by the same nutritionist each time. Values obtained for calories, fat (total, animal and plant), cholesterol and percentage of total fat from animal sources were compared for diet histories taken by the two nutritionists and with values obtained for the group interviewed by the same nutritionist.

Dawber et al. found there was good agreement between values obtained by the two nutritionists who interviewed the same subjects. There were no significant differences in the mean values obtained for any of the dietary constituents. However, the range of correlation coefficients obtained for interviews conducted by different nutritionists was lower for most dietary constituents than the range for the same nutrients in the sample of subjects interviewed two years apart by the same person. For subjects interviewed by two different nutritionists, the range of coefficients was .27 (percent calories from fat) to .90 (grams animal fat). For subjects interviewed by the same person, the range was .65 (cholesterol) to .92 (total calories). These findings indicate that while differences are not statistically significant, the diet history is slightly more reliable when the same person conducts repeat interviews.

The accuracy of the diet history method is subject to the limitations of both the 24-hour recall and the food frequency methods, since kinds-and-quantities data are obtained for a typical day followed by a frequency-type crosscheck. No study has attempted to determine the accuracy of the entire diet history method. One study by Moore et al. (1967) examined part of the issue by investigating whether estimation of the usual quantities of food consumed is improved with food models. The models used were constructed to resemble the way food is ordinarily served and eaten--i.e., from glasses, cups, spoons and in slices or "piles" of various sizes and shapes. Two different nutritionists conducted interviews with 30 husband-wife pairs using the same protocol. Only three food items were tested: milk, rice, and kidney beans. Experience had shown that these foods are particularly difficult to quantify. Usual intakes of the husband were assessed by one nutritionist with the husband as respondent. At the same time, in another room, the second nutritionist interviewed the wife for data on her husband's usual intake of the three foods. In the first part of the interview, questions were asked to assess quantities of the three foods. Then the questions were repeated using the series of graduated models. At this point, subjects chose the model that was most like the usual consumption. Following the interviews the nutritionists converted the model selections into equivalent volumes and weights. Differences between husband and wife reports were compared without regard to whether the difference was an over- or under-representation.

Exact agreement on all three items increased from 12 couples when only questions were used to 24 couples when the models were used. For those couples who continued to disagree, differences in the size of the estimates tended to decrease; for example, eight couples differed by more than one cup for one or more of the items with questions alone but only three couples had this large a disagreement when the models were used. Overall, improvements resulting from use of the models were greater for rice and beans than for milk, which is easier to estimate in glasses or cups. On most occasions, both men and women tended to select models representing larger amounts than they had previously described.

In addition to these objective comparisons, the nutritionists reported that when the models were used, less time was needed for the interviews and less frustration with estimating quantities was experienced by the subjects.

Period of Observation

The period of observation necessary to obtain reliable and valid estimates of nutrient intake depends, in part, upon the intraindividual variation that is typical for each nutrient. Although there are numerous studies reporting the food and nutrient intakes of children, most of them report group averages and do not consider intraindividual variations. Only four studies could be located in the literature that describe the variability of intakes for individual children as a feature of reliability of dietary assessment. Two of these studies (Widdowson, 1947; Huenemann & Turner, 1942) used weighed food records to estimate variations in calorie, protein, vitamin and mineral intakes. The other two studies (Eppright et al., 1952; Young et al., 1951) used estimated food records to determine the seasonal effects on the intake of these nutrients.

In all four studies, intakes of nutrients varied considerably for some children and certain nutrients varied more than others. Caloric intakes appear to be more stable from day to day than intakes of vitamins and minerals. In the study by Huenemann and Turner, over 50 percent of 25 children aged 6 to 16 had average caloric intakes that were within 20 percent of one another over four periods of 10 to 14 days each during a one-year interval. Protein and phosphorus intakes were the only other nutrients that agreed to this extent.

In Widdowson's study of 1,000 British children aged 1 to 18 years, the coefficient of variation in daily caloric intake over seven days ranged from a low of 10.6 percent in nine-year-old boys to a high of 20.5 percent in 16-year-old boys. Widdowson could find no consistent patterns in the intraindividual variation of caloric intake by age or sex but did notice that smaller intakes usually followed days of larger intakes. The variations were also observed to be related to factors such as physical activity and health status, but no formal tests were made of these relationships. In Widdowson's study, daily variations in the intake of most vitamins and minerals were larger than daily variations in the intake of calories.

Vitamins and minerals showing the most intraindividual variation were not always the same in the four studies, but generally, vitamin A and ascorbic acid were among those nutrients with the poorest agreement between periods of observation. For example, Huenemann and Turner found that over one-half of the children in their study had average intakes of these nutrients that differed by 60 percent or more from one period to another.

Seasonal variations are believed to be responsible for these differences. Eppright et al. obtained three-day estimated food records from 108 9- to 11-year-old children in Ohio and 53 10- to 12-year-old children in Kansas in the fall and spring. For the Ohio children, the largest difference between fall and spring intakes was for ascorbic acid. Mean intake for the group differed by 27.8 percent. Correlation coefficients to measure intraindividual variation were computed only for the Kansas sample. The highest coefficient, indicating the greatest similarity between fall and spring intakes of individual children, was for calories ($\underline{r}$=.50). The lowest coefficient, indicating the greatest difference between fall and spring intakes, was for vitamin A ($\underline{r}$=.08).

Participants in a study by Young et al. (1951) came from two urban schools and one rural school in New York State. Only the mean intakes for children grouped by age and sex are reported. Vitamin A, niacin, protein and riboflavin intakes were significantly higher for some groups of children in spring than in fall. For example, 7- to 9-year-old boys and girls had an 876 I.U. difference between fall and spring in their intake of vitamin A.

Studies have recently been conducted to assess variation in the intake of dietary constituents, such as fat, sodium and cholesterol, that are of interest in epidemiological investigations of cardiovascular disease. To date, these studies have been performed mainly on adults, but the findings suggest areas to investigate in future studies of dietary variations in child subjects.

Calories continue to show the least amount of intraindividual variation in several studies. In one study by Dawber et al. (1962), the correlation coefficient for calories in diet histories of 30 adult subjects taken two years apart was .92; in diet histories taken three-and-one-half years apart from 33 subjects, the correlation for calories was only slightly lower (.84).

Cholesterol and sodium appear to have high amounts of intraindividual variation. Beaton et al. (1979) found that intraindividual differences accounted for 73.2 percent of the variance in cholesterol, calculated from repeated 24-hour recalls obtained from 30 male and 30 female subjects. In the study by Dawber et al. (1962) quoted above, cholesterol intakes showed lower correlations between repeated diet histories than most other constituents. For example, in histories taken two years apart, the correlation between cholesterol intakes was only .65, compared with the correlation of .92 for calories.

A study by Hankin et al. (1967) is the only one known to have assessed intraindividual variation in sodium intake. Variations in the intake of calories, protein, carbohydrate and fat were also assessed. Mean intakes for each of seven days of a group of 93 male subjects expressed as coefficients of variation ranged from 25.2 to 28.8 percent for calories to 37.5 to 45.7 percent for sodium. According to the authors, correlation coefficients for the daily intakes of individuals were lower for sodium than for the other dietary constituents.

Several studies have shown that the amount of intraindividual variation for calories and most nutrients decreases as longer periods of intake are assessed. Acheson et al. (1980) found that coefficients of variation for the caloric intake of two adult subjects were much lower when averaged over a year's time compared with a single day. Chappell (1955) also found lower coefficients of variation for most nutrients, including vitamin A and ascorbic acid, as the period of observation increased. In an analysis of her own intake, Chappell found the coefficient of variation for vitamin A was 24.9 percent over one week and 12.2 percent over 12 weeks. For ascorbic acid, the coefficients dropped from 24.3 percent over one week to 9.9 percent over 12 weeks.

These findings indicate that fluctuations in highly variable nutrients such as vitamin A and ascorbic acid average out when a sufficiently long period of intake is observed. The number of days of observation required to obtain accurate estimates of the usual intake will differ for each nutrient according to the amount of variation that is typical for that nutrient and the degree of precision desired. In general, longer periods of observation will be required to obtain more precise estimates for nutrients that show large intraindividual variations.

Chalmers et al. (1952) used data collected from several samples of adult subjects to determine how many days a dietary record should include when dietary intake is estimated for a group and for an individual. The authors conclude that, for calories, protein, calcium, iron, thiamin, niacin and riboflavin, a one-day record (or recall) will give an estimate of the average group intake that is within about 25 percent of the true average intake 95 out of 100 times, if each sample contains ten subjects. Greater precision can be achieved by increasing the number of subjects in the group. For example, with 60 subjects the average intake is expected to be within 10 percent of the true intake 95 out of 100 times.

The number of days required to estimate the intake of an individual differs according to sex. Chalmers et al. calculate that for men, 14 days of records would be necessary to assure that the estimated intake of calories and the six nutrients listed above is within 15 percent of the actual intake in 95 out of 100 measurements. To obtain the same precision for females, only about 11 days of records would be required.

None of these estimates apply to ascorbic acid and vitamin A. Chalmers et al. calculated that approximately six subjects must be added to group studies and 10 percent more days must be added to individual studies to obtain accurate estimates of ascorbic acid intake. The variability of vitamin A is such that Chalmers et al. believe it cannot be accurately assessed in dietary surveys.

Balogh et al. (1971) did a similar study to determine the number of daily records that should be kept to obtain accurate estimates for calories, fat, cholesterol, starch, sugar, and the various types of fatty acids. These investigators used 24-hour recalls repeated on random days each month over a year's time. Subjects were 90 adult volunteers. By examining coefficients of variation, Balogh et al. concluded that unbiased estimates for individuals are not likely to be derived from data collected for less than about six months using the random repeat 24-hour recall technique; for some constituents, almost a whole year would be required. The authors used only data from individuals who had provided recalls for eight months or more to estimate how many random recalls would be required for each constituent to assure with 95 percent confidence that the average intake of an individual is within 20 percent of the true individual mean.

To obtain this precision for subjects with little variability in their daily intakes, the number of required recalls ranged from 4 for total calories to 20 for cholesterol and 23 for linoleic acid. To obtain the stated precision for subjects with more variability in their daily intakes, the number of required recalls ranged from 9 for total calories to 44 for linoleic acid and 45 for cholesterol. Note that Balogh et al. were writing about attaining a particular standard of precision for an individual's dietary intake, and that it is not necessary to use so many recalls for obtaining reasonable precision for group means.

Comparisons Among Methods

Fifteen studies have compared estimates of dietary intake obtained by the various dietary assessment methods. A major objective of these studies is to determine whether nutrient intakes obtained by one method over- or underestimate intakes obtained by another method. A summary of findings from the 15 studies is presented in Table II-1. In most studies the criterion method was either the weighed food record or the estimated food record; however, some studies have used the diet history as the criterion for the 24-hour recall or the 24-hour recall as the criterion for the food frequency.

Diet History. Whatever criterion is used, the diet history method appears to overestimate average values for most nutrients. This conclusion is generally attributed to Young et al. (1952a) as a result of their comparison of the diet history method with the estimated food record. However, overestimates using the diet history were also obtained by Lubb (1968) in comparison with weighed food records and Young et al. (1952b) in comparison with the 24-hour recall. The magnitude of differences obtained by the diet history and other methods varies. Most discrepancies in the studies by Young et al. were greater than 20 percent. In Lubb's study, the discrepancy was much smaller, with only vitamin A and ascorbic acid differing by more than 10 percent. Trulson (1954) found that in comparison with estimated records the diet history overestimated milk consumption, but showed good agreement with other food groups. Huenemann and Turner (1942) found that subjects both over- and underestimated food quantities and omitted some foods altogether.

24-Hour Recall. The 24-hour recall has been compared to the weighed food record, the estimated food record, and the diet history. Underestimates are frequently noted for the 24-hour recall, but the nutrients affected vary by study and not all researchers find the same results. Five of the studies found that the 24-hour recall underestimates calories. Young et al. (1952b) showed that the 24-hour recall overestimated calcium, vitamin A, ascorbic acid and riboflavin, but Gersovitz et al. (1978) found that it overestimated only protein. Trulson (1954) found no significant differences in mean protein values obtained by recalls and estimated food records. Stevens et al. found that the 24-hour recall underestimated protein and calcium compared to the diet history method.

Table II-1. Results of Studies Comparing Different Methods of Dietary Assessment

Criterion Method and Studies	Estimated Record	Diet History	24-Hour Recall	Food Frequency
WEIGHED FOOD RECORD:				
Huenemann and Turner (1942) Diet history vs. weighed food record in sample of 25 children.		Overestimates and underestimates depending on specific nutrient.		
Lubb (1968) Diet history vs. weighed food record in sample of 30 7-year-old children.		Overestimates all nutrients except niacin; but only vitamin A and vitamin C have differences greater than 10%.		
Adelson (1960) 24 hr. recall* vs. weighed food records in sample of 59 male adult subjects. (*Recalls taken for 7 days during same period as records were kept.)			Underestimates calories but variable pattern for other nutrients.	
Acheson et. al. (1980) 24 hr. recalls* vs. weighed food records in sample of 12 adult subjects. (*Recalls were self-administered without food models.)			Underestimates calories; other nutrients not reported.	

Table II-1. Results of Studies Comparing Different Methods of Dietary Assessment (Cont'd)

Criterion Method and Studies	Estimated Record	Diet History	24-Hour Recall	Food Frequency
WEIGHED FOOD RECORD:				
Thomson (1958) 24-hour recall vs. weighed food record in sample of 20 pregnant women.			Underestimates calories.	
Gersovitz et al. (1978) 24-hr. recall vs. 7-day estimated food record vs. weighed consumption of one meal in a sample of 65 elderly subjects.	Underestimates calories and thiamin but no differences for other nutrients.		Overestimates protein but no differences for other nutrients.	
ESTIMATED FOOD RECORD:				
Young et al. (1952a) Diet history vs. estimated records in 6 different samples of subjects.		Overestimates calories and 8 nutrients.		
Young et al. (1952b) Diet history vs. 7-day estimated food record vs. 24-hour recall in 3 different samples of subjects. (Grade school children, high school and college students and pregnant women.)			Overestimates all nutrients but only calcium, vitamin A, ascorbic acid and riboflavin show differences greater than 10%.	

Table II-1. Results of Studies Comparing Different
Methods of Dietary Assessment (Cont'd)

Criterion Method and Studies	Estimated Record	Diet History	24-Hour Recall	Food Frequency
ESTIMATED FOOD RECORD:				
Trulson (1954) Diet history vs. 7-day record vs. 24-hr. recall in sample of 37 clinic patients. (Children ages 7-12 and 13 and older.)		Overestimates milk intake; no significant differences for other food groups or protein.	No significant differences for food groups or protein.	
Balogh et al. (1968) Food frequency vs. diet history vs. 7-day record* in samples of 48 and 14 adult subjects. (*Estimated record with weighing of some foods)				No significant differences for calories, protein and fat.
Madden et al. (1976) 24-hr. recall vs. observed consumption of one meal in sample of 76 elderly subjects.			Underestimates calories but no difference for other nutrients.	
DIET HISTORY:				
Stevens et al. (1963) 24-hour recall vs. diet history in sample of 74 adult subjects.			Underestimates protein and calcium; variable pattern for calories, fat, vitamin A and ascorbic acid.	

Table II-1. Results of Studies Comparing Different Methods of Dietary Assessment (Cont'd)

Criterion Method and Studies	Estimated Record	Diet History	24-Hour Recall	Food Frequency
DIET HISTORY:				
Stefanik and Trulson (1962) Food frequency vs. diet history vs. estimated record in 2 samples of adult subjects.				No significant differences in average number of times food items were reported.
Epstein et al. (1970) Food frequency vs. diet history in sample of 161 adults grouped by age, sex, and country of origin.				Underestimates calories and carbohydrates; variable patterns for fat constituents.
24-HOUR RECALL:				
Hunt et al. (1979) Food frequency vs. 24-hour recall* in sample of 50 adult subjects. (*5 recalls/subject taken once/week over 5 consecutive weeks.)				Overestimates most nutrients but difference is less than 10% for calories, protein, carbohydrate and niacin.

Both Madden et al. (1977) and Gersovitz et al. (1978) found that the 24-hour recall exhibits the "flat-slope syndrome." This phenomenon results from a tendency for persons with low intakes to overreport food consumption and persons with high intakes to underreport food consumption. Gersovitz et al. showed that flat-slope syndrome does not occur in the first three days of a study using a seven-day estimated food record, but that it appears as the days of recordkeeping progress.

The flat-slope syndrome diminishes the difference in mean values obtained for two groups of subjects. Madden et al. and Gersovitz et al. point out that this can affect evaluation studies that compare the nutrient intakes of program participants with nonparticipants. The tendency to underreport large intakes and overreport small intakes increases the chance that data from 24-hour recalls will produce "false negative" results--that is, a failure to detect a real difference when one actually exists, or an underestimate of the magnitude of the difference between the two groups. There is less likelihood of producing a "false positive" result when comparing the two groups; that is, it is not likely that a difference will appear when, in fact, none exists. The consequence of the flat-slope syndrome is that when a significant difference is detected between program participants and nonparticipants in dietary data obtained from recall, one can be fairly confident that the program has had an impact on dietary behavior. However, if no difference is found, the conclusion is less certain. It is possible that the program had an effect, but the method was unable to detect it.

Food Frequency. If the diet history tends to result in overestimates and the 24-hour recall tends to result in underestimates, the food frequency tends to fall somewhere in between.

Stefanik and Trulson (1962) compared the number of times food items were mentioned on diet histories and on estimated food records from different samples of subjects with the number of times the same items were coded on a food frequency questionnaire. Although there were few cases of exact agreement, most differences were insignificant. The authors concluded that the food frequency gives qualitative results that are similar to the history and record methods.

The question of whether the food frequency gives quantitative results that are comparable to other methods was investigated by Balogh et al., 1968; Epstein et al., 1970; and Hunt et al., 1979. In the study by Balogh et al., close agreements for individual intakes of calories and the various constituents of dietary fat were found between the food frequency and the diet history methods and between the food frequency and the seven-day food record. The subjects of this study were adult males with homogeneous backgrounds who were participating in a study of heart disease. To determine whether the same results would be obtained from a more heterogeneous group of subjects, Epstein et al. compared amounts of calories and dietary fat constituents obtained by food frequency and dietary histories from 161 subjects representing different ages, sexes and countries of origin. These investigators found that correlations differed among the various groups of subjects. None of the correlations were as high as in the study by Balogh et al. Mean daily intakes from the food frequency method were lower than means obtained from the history. The difference was greatest for persons with the most varied diets. The authors concluded that the food frequency method could not provide valid quantitative estimates of nutrient intakes in heterogeneous populations or in populations consuming a varied diet.

Hunt et al. also concluded that the food frequency cannot be used to obtain quantitative data. Hunt et al. compared average intakes computed from five 24-hour recalls taken from each of 50 adult subjects once a week for five consecutive weeks with average intakes computed from the food frequency questionnaire. Significant but only moderately high correlations were found for calories, vitamins and minerals. For most nutrients, the food frequency gave group averages that were 16 to 28 percent higher than group averages obtained from the recalls.

Discussion

Studies that have addressed reliability and validity considerations in the selection of dietary assessment methods have evaluated the accuracy of the methods, determined the number of days required for estimates of individual and group intakes, and compared results of the various methods with one another. Analysis in the latter approach has attempted to measure the discrepancy that exists in the quantities of foods or nutrients obtained by the various methods and characterize them in terms of over- or underestimation.

The component of accuracy that is affected by measurement error has been studied by several investigators. It is generally concluded that data collection requirements of the weighed food record cause subjects to alter their usual food behavior (Burke & Pao, 1976). Several investigators have also shown that considerable measurement error can occur in estimated food records (Huenemann & Turner, 1942; Young et al., 1953b; Hankin et al., 1967; Lockwood et al., 1968). Good reproducibility can be obtained with 24-hour recalls used with children (Frank et al., 1977) and adults (Beaton et al., 1979) when trained interviewers use standardized protocols. The same conclusion is warranted for diet histories taken from adults (Dawber et al., 1962).

Several factors affect the accuracy of measurements. Foods that are eaten in standard portion sizes such as slices, glasses or cups appear to be measured or recalled more accurately than foods served in "piles," "mounds," or "handfuls" (Moore et al., 1967).

It has been shown that intake amounts obtained from 24-hour recalls are substantially higher when probes are used by interviewers (Campbell & Dodds, 1967). It has also been shown that the use of graduated food models increases the portion size estimates by subjects (Moore et al., 1967).

A limited number of studies have tested the ability of children to take accurate measurements or to recall accurately the amounts of foods consumed. There is evidence that children can give accurate information by recall (Bransby, 1948; Meredith, 1951) and by estimated food records (Young et al., 1953b) when they are aware that a study is taking place. However, estimated records may be less accurate when children are not prepared for the study (Young et al., 1953b).

The ability to produce an accurate recall improves with the age of the child. Children in grade 4 recalled 20 percent more foods in their school lunch than children in grade 1, according to one study (Emmons & Hayes, 1973). However, it is not clear that mothers would be able to provide more accurate information for the younger children. In the study by Emmons and Hayes, there were fewer significant correlations between mother and child recalls for a 24-hour period in grades 1 to 2 than in grades 3 to 4. As the authors note, this analysis does not indicate which respondent was more accurate, since food actually consumed by the child for the 24-hour period was unknown. There is no good indication from other studies whether dietary data on children in grades 1 to 2 should be taken from the mother or the child, but the conclusion of Emmons and Hayes is that children in grades 3 and above "can give comprehensive dietary information" (p. 415).

The length of time to be covered by a dietary assessment depends upon the amount of intraindividual variation that occurs in the intake of various nutrients, the precision desired, and whether the data will be evaluated for individuals or groups. Studies have shown that vitamin A and ascorbic acid show considerable day-to-day and seasonal variation in the diets of children

(Widdowson, 1947; Hueneman and Turver, 1942; Eppright et al., 1952; Young et al., 1951). Cholesterol and sodium intakes also exhibit large daily variations in the diets of adults (Beaton et al., 1979; Hankin et al., 1967).

Only two studies have actually attempted to specify the number of days of observation needed to obtain valid estimates of various dietary constituents. According to Chalmers et al. (1952), a one-day food record or recall is sufficient to characterize the intake of groups of 60 subjects or more within 20 percent of their actual intake for calories, protein, calcium, iron, thiamin, niacin and riboflavin. Approximately 10 percent more subjects should be added to the sample to obtain the same precision for estimates of ascorbic acid.

Valid estimates of nutrient intakes of individuals cannot be obtained from a one-day record or recall. Depending on the precision desired, several weeks or months of observation may be required to obtain valid estimates for highly variable dietary constituents such as ascorbic acid (Chalmers et al., 1952) and cholesterol (Balogh et al., 1971). Vitamin A is so variable that it may not be possible to obtain valid estimates of this nutrient for either groups or individuals (Chalmers et al., 1952).

Both the accuracy with which the data are collected and the period of observation affect the degree to which dietary data obtained by different methods compare with one another. When data from weighed or estimated food records are used as the criteria, the 24-hour recall tends to underestimate food and nutrient intake (Adelson, 1960; Acheson et al., 1980; Thomson, 1958; Madden et al., 1976). The tendency for persons with low intakes to overreport food consumption and persons with high intakes to underreport food consumption causes a flat-slope syndrome in 24-hour recall data that can obscure real differences among groups of subjects.

Dietary histories tend to overestimate food and nutrient intakes as compared with data from weighed and estimated records (Lubb, 1968; Young et al., 1952a; Trulson, 1954). Different estimates are obtained for the food frequency depending on the method to which it is compared. No significant differences are found where numbers and kinds of food items are compared rather than the quantity of intake (Stefanik & Trulson, 1962). Quantities may also agree when the dietary habits of the population are homogeneous (Balogh et al., 1968); but in heterogeneous groups, the food frequency underestimates intake compared with the diet history (Epstein et al., 1970) and overestimates intake compared with the 24-hour recall (Hunt et al., 1979). Also, while the frequency with which a food is consumed roughly corresponds with quantity, there is less agreement when food groups rather than separate items are assessed (Abrahamson et al., 1963). This means that intake of food assessed under broad group headings (e.g., fruits, vegetables, cereal, meat, etc.) will be less accurate and will reduce the degree of correspondence obtained between a food frequency questionnaire and other more quantitative methods.

FEASIBILITY AND COST

To a large extent the feasibility of methods of collecting dietary data is a function of the degree of cooperation that can be expected from the subjects. Cost also determines feasibility, since what is possible in a large-scale study is frequently constrained by the budget. Principal components of cost in dietary surveys are the level of expertise required of persons assigned to collect the data and the time required for data collection, coding and analysis. Analysis costs are contingent upon whether food nutrients are obtained from chemical analysis or calculations based on tables of nutrient composition. The differences between these two methods are discussed in the following section of this review.

Weighed Food Record

According to Pekkarinen (1970), expenses in a dietary survey are highest when outside investigators are used for the precise weighing method. One person is able to weigh the food of only a few people at a time. Keys (1979) described the experience of the Seven Country Study. In this study, one dietitian obtained data from two families per week by living with one family and walking to the other family's home at mealtimes. The method is practical in rural, unindustrialized areas where mealtimes are regular and most people consume all food at home, but it is not feasible for large-scale surveys in the United States.

The time spent by data collectors in the field can be reduced if subjects weigh their own food, but the cost of supplying each subject with a scale must be considered. Furthermore, according to Marr (1971), this method still requires some supervision by the investigators. Marr quotes studies in which supervision ranged from daily visits throughout data collection to one contact at the beginning and one at the end of the data-collection period. In Adelson's study (1960), the initial visits to train subjects averaged one hour, and three shorter visits were made during the week of recordkeeping. Den Hartog et al. (1965) used one dietitian for every five families involved in keeping weighed records for one week. The costs of supervision will increase proportionally to the number of days covered by the study. The authors of various reviews do not state what expertise is required of supervisors. Dietitians were used in most studies.

Estimated Food Record. Marr (1971) believes that direct daily supervision of subjects using an estimated food record is not required, but that a detailed interview is desirable to check the subject's ability to make accurate measurements. In a study that extends beyond two or three days, more accuracy may be obtained if investigators make follow-up visits to the home. In a study by Eppright et al. (1972), investigators visited each home at least twice. Improved accuracy is also obtained when subjects are supplied standard sets of household measures.

Estimated food records may involve higher data processing costs than weighed records, since household measures must be converted to metric equivalents (Burke & Pao, 1976). However, some computerized nutrient data bases are programmed to make this transformation.

24-Hour Recall. The costs of conducting a 24-hour recall vary according to the time, personnel and equipment. The least expensive means of obtaining data is to allow subjects to self-report their intakes on a blank sheet of paper; however, as shown by Adelson et al. (1980), the accuracy of results will suffer from a lack of supervision. Recalls of 24-hour consumption can take as little as 30 minutes using trained interviewers (Burke & Pao, 1976). The HANES interview, which included both the 24-hour recall and a food frequency index, was conducted in 30 minutes (Youland & Engle, 1976).

There is some difference of opinion about the level of personnel required to conduct the interview. Persons with dietetics backgrounds are familiar with food varieties, forms of purchase and methods of preparation, but there is concern that their experience has led to the development of firmly entrenched styles of interviewing. It may be difficult for these people to adhere to a standardized protocol if it differs from their own developed standards. It appears that the ability to establish rapport with the subject, follow directions and record data accurately are the most important characteristics of persons who will serve as interviewers for the 24-hour recall, provided that it is possible to assure adequate training and quality control.

Besides costs of training, other potential costs are in the types of food models and other visual aids used in the interview. Homemade models, such as those described by Moore et al. (1967), are fairly inexpensive but take time to construct. Lifelike replicas are commercially available, but may cost several hundred dollars a set.

Food Frequency. The time required to administer a food frequency questionnaire will depend upon the number of separate food items on the list and whether quantities as well as frequencies are assessed. A short form such as that used in HANES can be administered in five to ten minutes. The food frequency interview described by Balogh et al. (1968) included an assessment of quantities using food models and household measures. The number of food items on the list is not reported, but the authors state that the interview usually took 15 to 20 minutes. However, a few subjects had the habit of repeating each question and thinking about it before answering. For these subjects, the time needed to complete the interview was two to three times longer than usual.

Although food frequency questionnaires can be self-administered, most research studies report that the interview was conducted by nutritionists. Balogh et al. used nurses and Epstein et al. (1970) used lay interviewers to administer the questionnaire. Balogh et al. say that the nurses were chosen on the basis of personality and their ability to listen. Three days of intensive training by a nutritionist were provided, and each interviewer was given a field manual containing interviewing and coding instructions. Also, the nutritionist made random observations of the interviews for quality control.

Diet History. Since the diet history contains so many variable procedures, the time costs of conducting an interview are difficult to specify. Estimates vary from 20 to 60 minutes per subject. Pekkarinen (1971) says that the average is 30 minutes in most surveys and that an experienced interviewer is able to interview 10 to 12 persons per day in one location. Pekkarinen also claims that the method is cheap compared to other methods, since it does not require large numbers of trained personnel. However, according to Burke (1947), "the ideal person to take dietary histories in research is the nutritionist with special training for that purpose" (p. 1042). Den Hartog et al. (1965) compared the work involved and the skill needed for diet histories with the time required to train and supervise subjects using weighed food records. These investigators concluded that the training and skill needed by dietitians was greater for the diet history method, since they have to gain the confidence of respondents, resolve discrepancies between the usual intake and the cross-check without leading the subject, and make judgments about the foods and portion sizes that represent the subject's characteristic intake.

Coding data can also be complicated in the diet history. Mann et al. (1962) report that coding procedures requiring a nutritionist to assign food and quantities to coded categories took approximately an hour and a half.

Discussion

The primary field costs incurred in dietary surveys are attributed to the level of expertise required of personnel and the time required for data collection, coding and analysis. Although there is some disagreement in the literature, it generally appears that diet histories require the most specialized expertise. Persons taking diet histories must possess knowledge about food and nutrition required to make judgments about the reliability of the data and subject's typical food intake. Food records, 24-hour recalls and food frequency interviews require less experienced personnel. The ability to establish rapport with subjects, to follow directions and perform--or teach subjects to perform--accurate measurements are the primary qualifications of data collectors for these methods, provided that adequate training and quality control procedures are adopted.

Field costs are highest in methods that require supervision of subjects in their homes over a prolonged period of time. They are lowest when data can be collected from several subjects at one location in a short period of time. In the order of highest-to-lowest field costs, the various methods of dietary assessment can be ranked as follows:

1. weighed food record by investigators
2. weighed food record by subjects
3. estimated food record
4. diet history
5. 24-hour recall
6. food frequency questionnaire

The order of field costs is affected by the accuracy desired. Obviously, greater accuracy is obtained by closer supervision and more thorough questioning. However, too much interference by the investigators risks altering the subjects' normal eating behavior or their tendency to provide truthful information.

Costs of equipment are usually minor in dietary surveys compared with other methods of nutritional status assessment, but they are a factor to be considered. Weighed food records require scales; estimated food records require household measures; and recall methods require food models. The costs of food models are most variable, since they depend on the types used.

All methods that estimate food portions in household measures may involve additional coding costs if household measures must be converted to metric equivalents by hand. This and other coding procedures can take as long as one-and-one-half hours of interviewer time per subject.

ANALYSIS OF DIETARY DATA

Chemical Analysis

Once a dietary data collection method has been selected, decisions must be made about ways in which the data will be analyzed. Some analyses require no more than simply grouping foods into various categories and counting the number of times various foods or food groups are consumed. Most studies, however, seek to determine the nutrient content of the food. The most accurate means of determining nutrient content is by chemical analysis (Marr, 1971; Eagles et al., 1966). In practice, chemical analysis is mainly used with methods that collect dietary data prospectively by weighing or estimating portion sizes as eaten. A duplicate serving or aliquot of each item is collected from each subject and a homoginate for an entire meal or an entire day is made. If the sample must be sent to a laboratory for later analysis, it is frozen and packed for shipment.

Theoretically, it is also possible to perform chemical analysis on foods obtained by recall methods. In this case, exact duplicates of the foods recalled by subjects are prepared from recipes or directly purchased.

In large-scale surveys, the costs of performing chemical analysis are prohibitive. Furthermore, it might even be argued that chemical analysis is not appropriate for field studies because dietary assessment, made as part of total nutritional assessment, should reflect average nutrient intakes rather than the nutrient content of a single sample of food.

Food Composition Tables

The nutrient content of food can also be estimated from tables of food composition. Using tables is less expensive than chemical analysis. The availability of computerized data bases has helped make values calculated from food composition tables the preferred method of analyzing dietary data in large-scale field studies.

Most, but not all, values in food composition tables are derived from several samples of the food. The average values, therefore, are not precise for amounts actually consumed by the subjects. The degree of correspondence between analyzed and calculated nutrient values has been the subject of several studies. Interpretation of the results is dependent on knowledge of the technology for determining the nutrient content of food and the variations in food composition that occur in different varieties, and different forms of preparation. These matters are beyond the scope of this chapter. However, Marr (1971) concluded after a brief review of the literature that absolute agreement is not achieved, and agreement for some nutrients is better than for others. Marr said that because there is a close association between calculated and analyzed values, it is possible to compare individual intakes relative to each other and to compare groups of individuals, both in terms of means and at the extremes of the distribution, for calories and most nutrients. In the studies reviewed by Marr, calories and protein had better agreement than fat and carbohydrate, but values for calcium and iron had the poorest agreement of all. No data are reported by Marr for agreement between calculated and analyzed values of vitamins, but their general properties indicate that values for cooked foods would agree less well for vitamins such as ascorbic acid (which are water soluble and heat labile) than for the more stable fat soluble vitamins, such as vitamin A.

Nutrient Data Bases

Description. There are approximately 35 different data bases that can be used to calculate the nutrient content of foods (Fisher, 1979). Most have been produced by and are available from government agencies or universities. Others are the private property of food manufacturing companies. At the Fourth Annual Nutrient Data Bank Conference (1979), participants discussed efforts to catalogue the features of all available data bases; at present, no such catalogue exists.

Most data bases that are available in the United States draw upon data that have been compiled by the United States Department of Agriculture. Agriculture Handbook No. 8 (Watt et al., 1963) is the USDA's standard reference on food composition. It contains nutrient data for over 3,000 different foods. Amounts of food energy, protein, fat, carbohydrate, crude fiber, calcium, phosphorus, iron, sodium potassium, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid are provided for 100-gram (edible) portions of food and for one pound as purchased. Handbook No. 8 also contains separate tables for the fatty acid composition of foods. The last complete revision of Handbook No. 8 was in 1963. A more recent series, Agriculture Handbook No. 456 (Adams, 1975), converts data from Handbook No. 8 into common household measures. Home Economics Research Report No. 36 (Orr, 1969) gives the amounts of pantothenic acid, vitamin B_6 and vitamin B_{12} in 100-gram edible portions and in one-pound amounts as purchased. Various portions of Handbook No. 8 and Handbook No. 456 are available to the public as computerized data bases.

Data in handbooks published by the Department of Agriculture are drawn from a variety of sources. Values for carbohydrate, fat and protein represent "proximate" composition. The fatty acid compositions are based on studies conducted before 1955 and do not use newer, more accurate methods, such as gas-liquid chromatography. Several methods have been used to obtain the mineral composition of foods. Sodium values include amounts added in processing, but do not include amounts that might be typically added at the table. Many foods listed in Handbook No. 8 have missing sodium values. It should also be noted that the published figures for nutrients are for the amounts present in the food, rather than the amounts actually available for metabolism. They do not take account of factors that influence absorption and utilization of the nutrients from food.

Various methods of vitamin analysis were used in compiling Handbook No. 8. Vitamin A values are based on physical-chemical determinations of total carotenoids or of individual carotenes and cryptoxanthin. These values are then converted to a composite expressed in international units (IUs). Niacin values are based on chemical and microbiological assay methods that measure free acid following release by enzyme, acid or alkali treatments. They do not include amounts of niacin available from tryptophan, an amino acid precursor of niacin that is found in protein. Vitamin C values for fresh, canned and dehydrated foods show reduced ascorbate only. Values for frozen foods show total ascorbic acid (i.e., both reduced and dehydroascorbic acid). Most figures probably underestimate amounts present, since data for some fresh products have variable but often large quantities of dehydroascorbic acid.

No comprehensive tables have as yet been compiled that include other known nutrients. However, separate listings for nutrients such as cholesterol (Fealey, Criner, & Watt, 1972), copper (Pennington & Calloway, 1973), zinc (Murphy, Wills & Watt, 1975), folacin (Perloff & Burtrum, 1977) and vitamin E (McLaughlin & Weihrauch, 1979) have been published. The Department of Agriculture is in the process of compiling these values into a revised edition of Handbook No. 8. To date, revised values have been released for herbs and spices, dairy and egg products, baby foods, fats and oils, poultry products, and soups, sauces and gravies. In addition to the nutrient values for these foods, the new editions of the handbook give the number of food samples used in the analysis and the standard deviations.

Data in the handbooks are given for "generic" foods rather than for brand name products. There are few values listed for combination or "convenience" items. Many of the combination items are assumed to be made "from scratch." No values are available for fast foods or the many processed foods that have entered the market in recent years. Because of these deficiencies, most data bases available for dietary analysis supplement data from Handbook No. 8 with data obtained from other published sources and from food manufacturers.

Practical Considerations in the Selection and Use of Nutrient Data Bases. Because data are obtained from numerous sources, there is generally poor agreement among the various data bases when nutrient values for the same foods are compared. This was recently shown in a study comparing values obtained for a common menu using different data bases (Hoover, 1980). Although details of the study are not reported, a wide range of values for all nutrients was found. According to the author, possible reasons for the discrepancies may be related to coding the menu, portion size calculations, data base loading and program algorithms as well as different sources of nutrient data.

These findings imply that the particular data base selected for the analysis of dietary data will have an effect on the results. A project jointly sponsored by the USDA and the University of Missouri is currently underway to develop a diagnostic tool which will facilitate detection of various sources of error in the various nutrient analysis systems (Hoover, 1980). Until the tool is available, users must assess each data base individually.

Aside from the problems of accuracy occasioned by the different data sources used for nutrient analysis, there are other practical considerations in the selection of data bases. Three major concerns are the compatibility of the software with the protocols for collection of the dietary data, the amount of data transformation required, and the kinds of outputs that are produced.

In some systems, the software is specific to the data input, thus making it necessary for the data base and the protocols to coincide. For example, the data base used in HANES is programmed to convert data input as food model portion equivalents to nutrient composition. Use of this system demands that the HANES set of food models be used.

A substantial time cost is incurred if data collected from the subjects must be tranformed before it is input into the nutrient analysis system. The most time consuming transformations usually involve assigning code numbers to the foods, converting the household portion sizes to metric equivalents and keypunching the data. This labor can be saved by using pre-coded data forms such as those developed for 24-hour recalls in conjunction with the Nutrient Diet Data Analysis (NDDA) system (Endres et al., 1979). This system uses optical scanning, which allows the computer to transform marks on a specially designed form to food codes and amounts for automatic analysis. Interviewers mark boxes on the form that indicate portion sizes of each food. Food models correspond to the portion sizes on the form. The system saves time and minimizes coding errors, but the form is designed to cover an entire 24-hour period. It is not possible to separate data by meal or snack periods unless separate forms are used. Furthermore, coding quantities of food into precoded categories reduces the degree of resolution obtained for quantitative estimates which could mask small but real differences in consumption between groups. The NDDA systems represents a technological innovation in dietary methodology but, to date, its most practical application is in medical settings where dietary data can assist in counseling patients with nutrition-related problems. It has not been widely used in research requiring highly specific, quantitative data analysis.

Outputs from different nutrient analysis systems also vary. Most data bases contain the nutrients included in Handbook No. 8, but other nutrients such as vitamin E, folic acid, vitamin B_{12}, vitamin B_6, zinc, copper, and magnesium are not contained in all systems. Neither are cholesterol and constituents of dietary carbohydrate and fat. For some of these nutrients, values for many foods are not known. It is important to determine whether the data base contains missing values for these nutrients or whether values have been imputed for some foods. A large number of missing values for a nutrient will result in underestimates of the amount of that nutrient that is consumed.

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Imputed values are not necessarily accurate; therefore, the results cannot be considered absolute.

Another output feature is the conversion of nutrient intake to percentages of Recommended Dietary Allowances. In order to obtain accurate estimates for the RDA, the age and sex of individuals must be entered with the dietary data. The user must also check which edition of the RDA has been used.

Discussion

Although chemical analysis provides the most accurate estimate of the nutrient content of food, values calculated from food composition tables are the only practical means of obtaining this information in large-scale surveys. The data in food tables do not always correspond to calculated values for the same food, but they provide close approximates for most nutrients and can be used to compare the intake of individuals and groups (Marr, 1971).

There are over 35 different nutrient data bases currently in use (Fisher, 1979). Each has different features regarding format for inputs, numbers of foods and nutrients that are analyzed, sources of data for these nutrients and the kinds of outputs that are obtained from the system. Most data bases include values from USDA Agriculture Handbook No. 8. Additional information on nutrient values is obtained from other published sources and from food manufacturers. Knowledge of the nutrients contained in the data base and the sources of information is important in selecting a nutrient analysis system. Other considerations are the compatibility of the system with dietary protocols and the kinds of data transformation required. These factors influence the cost of using the system and the amount of error that can potentially enter the system due to coding.

STANDARDS FOR DIETARY ASSESSMENT

Whatever method is chosen to collect dietary data, the information must be expressed in a way that facilitates meaningful interpretation. In studies of impacts of school nutrition programs, a common form of analysis is to compare various aspects of dietary intake between program participants and nonparticipants. These comparisons may focus on the kinds, amounts or frequencies of various food intakes or on the amounts of various nutrients that are consumed.

Assessment of Food Consumption

The simplest and least expensive methods are those that count or classify foods. They do not require the expensive step of converting food consumption into nutrient values. Counting foods can be done with data obtained from any of the dietary assessment methods, but it is most often used with the 24-hour recall or the food frequency. One common method is to categorize food reported on 24-hour recalls into food groups and compare intakes to recommended servings for each group. The Basic Four Food Groups (milk and dairy products, meat and other protein foods, fruit and vegetables, and breads and cereals) are usually used in such comparisons. The Basic Four specifies different numbers of servings from each group that should be eaten by children, teenagers and adults. The assumption in using the Basic Four as a standard is that diets that meet the pattern are nutritionally superior to those that do not.

This method can serve as a means of comparing the intakes of individuals or groups when only a crude estimate of nutrient adequacy is required. The method is unacceptable, however, when a more precise evaluation is needed, because foods within each of the Basic Four Groups vary widely in nutrient content. King et al. (1978) have shown that daily menus that meet the Basic Four requirements do not necessarily meet the Recommended Dietary Allowances (RDA) for all nutrients.

Food frequency data can also be analyzed according to the number of times various foods or food groups are typically consumed by program participants and nonparticipants. Aside from the Basic Four, there are no generally recognized standards for evaluating the frequency of intakes of various foods, but interest usually centers on foods that are known to be high in certain constituents such as sugar, fat, cholesterol and salt. A set of Dietary Guidelines issued recently by the U.S. Department of Agriculture and the Department of Health and Human Services states that Americans should avoid eating "too much" of these foods. USDA has published a planning guide that lists foods high in sugar, fat, cholesterol and salt in an effort to reduce the frequency with which these foods are served in school lunch programs (USDA, 1980).

A recent innovation in dietary analysis is to express intakes in terms of nutrient densities. The formula for nutrient density may be a simple expression of the nutrient intake in relation to calories or may involve calculations that relate a nutrient-and-calorie intake to the dietary allowances (Sorenson & Hansen, 1975). The advantage of this method is that it allows both qualitative and quantitative comparisons to be made. By comparing nutrient densities of individuals or subgroups with densities that are typical for the population as a whole, one can determine whether low intakes of given nutrients are the result of insufficient quantities of total food or the result of poor food choices. The nutrient density approach can be applied to individual foods as well as to total intakes and has been recommended as a means of defining "nutritious" foods (Guthrie, 1977).

Assessment of Nutrient Intake

The usual way to analyze dietary data requires the conversion of foods to their nutrient equivalents. The distribution of intakes for each nutrient can then be examined and the mean or median intakes of groups can be compared.

As a caution when interpreting the practical significance of statistically different mean values between groups, it should be pointed out that there is no apparent advantage in consuming nutrients in excess of body requirements and, for some nutrients, very high intakes can result in toxicity. Therefore, if mean values are well above requirements, statistically significant differences among groups may have no practical meaning for health promotion.

The most frequently used standards for evaluating dietary intake in relation to requirements are the Recommended Dietary Allowances (National Research Council, 1980). Revised editions of the RDA have been published every five or six years since 1943. The most recent edition of the RDA (1980) is shown in Table II-2. These allowances set levels of intake for nutrients that provide adequate nutrition for most healthy persons in the United States. Except for calories, the built-in "margins of safety" set the allowances approximately two standard deviations above the average requirement for healthy individuals. For some age-sex groups, particularly children, there is insufficient information about the variability of individual requirements to use two standard deviations as the margin. In these cases, judgments are made as to the appropriate level at which to set the allowance. The allowance for energy (calories) is treated differently because an excess of energy leads to obesity and may be detrimental to health. Recommendations for energy are estimates of the average needs of population groups, not the recommended intakes for individuals. These needs vary from person to person and cannot be established for individuals without detailed information about physical characteristics and activity patterns (National Research Council, 1980).

Not all surveys use the RDA for evaluating dietary intake. Large-scale surveys conducted in the United States, such as the Ten State Nutrition Survey (Center for Disease Control, 1972) and the Health and Nutrition Examination Survey (NCHS, Abraham et al., 1974), constructed their own

Table II-2. Food and Nutrition Board, National Academy of Sciences-National Research Council Recommended Daily Dietary Allowances,[a] Revised 1980

	Age	Weight		Height		Energy	Protein	Fat-Soluble Vitamins				Water Soluble Vitamins								Minerals					
								Vitamin A Activity		Vitamin D	Vitamin E Activity[e]	Ascorbic Acid	Folacin[f]	Niacin[g]	Riboflavin	Thiamin	Vitamin B_6	Vitamin B_{12}	Calcium	Phosphorus	Iodine	Iron	Magnesium	Zinc
	(years)	(kg)	(lbs)	(cm)	(in)	(kcal)[b]	(g)	(RE)[c]	(IU)	(IU)	(IU)	(mg)	(μg)	(mg)	(mg)	(mg)	(mg)	(μg)	(mg)	(mg)	(μg)	(mg)	(mg)	(mg)
Infants	0.0–0.5	6	14	60	24	kg × 117	kg × 2.2	420[d]	1,400	400	4	35	50	5	0.4	0.3	0.3	0.3	360	240	35	10	60	3
	0.5–1.0	9	20	71	28	kg × 108	kg × 2.0	400	2,000	400	5	35	50	8	0.6	0.5	0.4	0.3	540	400	45	15	70	5
Children	1–3	13	28	86	34	1,300	23	400	2,000	400	7	40	100	9	0.8	0.7	0.6	1.0	800	800	60	15	150	10
	4–6	20	44	110	44	1,800	30	500	2,500	400	9	40	200	12	1.1	0.9	0.9	1.5	800	800	80	10	200	10
	7–10	30	66	135	54	2,400	36	700	3,300	400	10	40	300	16	1.2	1.2	1.2	2.0	800	800	110	10	250	10
Males	11–14	44	97	158	63	2,800	44	1,000	5,000	400	12	45	400	18	1.5	1.4	1.6	3.0	1,200	1,200	130	18	350	15
	15–18	61	134	172	69	3,000	54	1,000	5,000	400	15	45	400	20	1.8	1.5	2.0	3.0	1,200	1,200	150	18	400	15
	19–22	67	147	172	69	3,000	54	1,000	5,000	400	15	45	400	20	1.8	1.5	2.0	3.0	800	800	140	10	350	15
	23–50	70	154	172	69	2,700	56	1,000	5,000		15	45	400	18	1.6	1.4	2.0	3.0	800	800	130	10	350	15
	51+	70	154	172	69	2,400	56	1,000	5,000		15	45	400	16	1.5	1.2	2.0	3.0	800	800	110	10	350	15
Females	11–14	44	97	155	62	2,400	44	800	4,000	400	12	45	400	16	1.3	1.2	1.6	3.0	1,200	1,200	115	18	300	15
	15–18	54	119	162	65	2,100	48	800	4,000	400	12	45	400	14	1.4	1.1	2.0	3.0	1,200	1,200	115	18	300	15
	19–22	58	128	162	65	2,100	46	800	4,000	400	12	45	400	14	1.4	1.1	2.0	3.0	800	800	100	18	300	15
	23–50	58	128	162	65	2,000	46	800	4,000		12	45	400	13	1.2	1.0	2.0	3.0	800	800	100	18	300	15
	51+	58	128	162	65	1,800	46	800	4,000		12	45	400	12	1.1	1.0	2.0	3.0	800	800	80	10	300	15
Pregnant						+300	+30	1,000	5,000	400	15	60	800	+2	+0.3	+0.3	2.5	4.0	1,200	1,200	125	18+[h]	450	20
Lactating						+500	+20	1,200	6,000	400	15	80	600	+4	+0.5	+0.3	2.5	4.0	1,200	1,200	150	18	450	25

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[a] The allowances are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods in order to provide other nutrients for which human requirements have been less well defined. See text for more detailed discussion of allowances and of nutrients not tabulated. See Table I (p. 6) for weights and heights by individual year of age.

[b] Kilojoules (kJ) = 4.2 × kcal.

[c] Retinol equivalents.

[d] Assumed to be all as retinol in milk during the first six months of life. All subsequent intakes are assumed to be half as retinol and half as β-carotene when calculated from international units. As retinol equivalents, three fourths are as retinol and one fourth as β-carotene.

[e] Total vitamin E activity, estimated to be 80 percent as α-tocopherol and 20 percent other tocopherols. See text for variation in allowances.

[f] The folacin allowances refer to dietary sources as determined by *Lactobacillus casei* assay. Pure forms of folacin may be effective in doses less than one fourth of the recommended dietary allowance.

[g] Although allowances are expressed as niacin, it is recognized that on the average 1 mg of niacin is derived from each 60 mg of dietary tryptophan.

[h] This increased requirement cannot be met by ordinary diets; therefore, the use of supplemental iron is recommended.

standards for dietary evaluation. These standards were derived from the RDA and other sources. For some nutrients (e.g., calcium), the standard values were set below the RDA values. Therefore, assumptions regarding the "margins of safety" built into the RDA may not apply. Because these modifications can influence the interpretation of results, reports of dietary studies should clearly indicate what standards are used to evaluate the data, how they differ from the RDA, and which edition of the RDA is being used.

In dietary assessments of individuals or population groups, intake of a given nutrient is usually expressed as a percentage of the standard. This has been called the Nutrient Adequacy Ratio (NAR) by some investigators (e.g., Hoagland 1978, 1980). When studies of population groups show that the average intakes of nutrients fall below 100 percent of the standards for a particular age-sex group, some individuals in the group can be assumed to be at risk for malnutrition. The relative degree of risk for two populations can be compared by examining the proportions that have NARs below 100 percent for each nutrient. However, the exact extent of malnutrition, as defined by the number of individuals who have inadequate dietary intakes, cannot be determined from dietary data alone. Furthermore, the method used to collect the dietary information can influence the prevalence estimates. All other things being equal, the shorter the period of observation, the greater the variability of intakes in the population will be. Therefore, the prevalence of low intakes will be higher when compared with a dietary standard than would be the case if longer periods were observed (Hegsted, 1975). Dietary data obtained by the 24-hour recall would be especially likely to overestimate the prevalence of low dietary intakes in the population.

Because an effort is made to set the Recommended Dietary Allowances above the average requirements of a population, it has been customary to consider intakes of individuals to be adequate if they equal at least two-thirds of the RDA (Jakabovitz et al., 1977). This conclusion can never be drawn from 24-hour recall data since, in previous sections of this review, the 24-hour recall method has been shown to be invalid for assessing the usual dietary intake of an individual. Even when habitual intakes of individuals are validly assessed, Hegsted (1978) contends that the adequacy of intake for an individual cannot be assessed from such data. When the two-thirds RDA cutoff is used, there will still be some individuals who need more than this amount. In summary, the intake of an individual in relation to the allowance is not by itself an indication of adequacy. Dietary evidence must be accompanied by clinical and biochemical evidence before conclusions regarding the status of an individual can be drawn.

Another analytic technique used in some studies is to calculate a Mean Adequacy Ratio (MAR) for individuals by truncating NARs at 100 percent and calculating the average NAR for all nutrients. This value is then treated as a continuous variable for statistical purposes. The MAR is a useful means of summarizing data for several nutrients, but its nutritional significance is questionable. The effects of consuming less than 100 percent of the RDA for various nutrients are not necessarily additive. Furthermore, mean values that result from slightly low intakes of several nutrients may not be as significant as mean values that result from a severely low value of a single nutrient.

Discussion

Several different methods are available to analyze food and nutrient data obtained from dietary surveys. Simple, inexpensive methods involve counting the kinds, amounts or frequencies of foods consumed by individuals or groups. The number of servings or the frequency of consuming various types of foods can then be compared with standards such as the Basic Four Food Groups or the USDA-HHS Dietary Guidelines. Such methods can be used to characterize the qualitative features of the diet, but provide only crude approximations of the adequancy of nutrient intake (King et al., 1978).

More quantitative methods require calculation of the nutrient content of foods. A recent innovation in dietary analysis expresses the nutrient content of individual foods or total intakes in terms of nutrient densities. This allows investigators to trace the cause of low intakes to inadequate total quantities of food consumed versus inappropriate food choices (Sorenson & Hansen, 1975).

Differences in the distribution of nutrient values can be compared among population groups. The significance of differences in mean values can be obscured by the flat-slope syndrome when data are derived from 24-hour recalls. Furthermore, a statistically significant difference in means may have little practical significance if all mean nutrient values are well above recommended allowances.

One of the most common forms of data analysis is to compare nutrient intakes with the Recommended Dietary Allowances. These allowances contain margins of safety which make it possible to conclude that most healthy individuals will have adequate intakes of nutrients if the allowances are met. The proportion of individuals whose intakes fall below the RDA can be taken as an indication of nutritional risk, but the exact incidence of inadequate intakes in the population cannot be known by this method, since data derived from relatively short periods of observation will overestimate the number of persons with low values compared with the RDA (Hegsted, 1977). The identification of individuals who have inadequate intakes is never possible from dietary data alone (National Research Council, 1980). Consequently, it is inappropriate to use cutoff points such as two-thirds RDA to categorize persons with adequate or inadequate intakes (Hegsted, 1978). The use of composite indexes such as Mean Adequacy Ratios has analytical value, but may have little practical meaning for the nutritional assessment of individuals or groups.

CONCLUSIONS

Each of the dietary assessment methods that potentially can be used to study the effects of school nutrition programs on the nutritional status of children has been evaluated in terms of participant cooperation, reliability, validity and cost. The evaluation shows that there is no totally satisfactory method of dietary assessment. Methods with the best ratings for reliability or validity tend to have the poorest cooperation ratings and the highest costs.

Weighed or estimated food records repeated over a year's time are best able to equalize the daily variations in dietary intake among individuals, but they require a great deal of patience from subjects and supervision from the data collectors.

According to Chalmers et al. (1952), a one-day record is sufficient to obtain valid estimates of intake of most nutrients for groups, but longer periods are necessary for valid estimates of the intake of nutrients for individuals. For some nutrients, such as vitamin A, it may be impossible to obtain valid estimates of intake for individuals no matter how many days are studied.

It has been shown that cooperation of subjects drops off markedly after three days of recordkeeping (Gersovitz et al., 1978), but that good cooperation is obtained with three-day records (Dierks & Morse, 1965). Estimated food records are also less likely to exhibit the flat-slope syndrome in the first three days (Gersovitz et al., 1978). It might be concluded, therefore, that the most reliable and valid estimate of nutrient intake that captures individual and seasonal variations is a three-day record repeated several times during the year. The problems of cooperation and cost of this method would make it infeasible in large-scale studies requiring probability samples, but it would be the method of choice in smaller longitudinal studies. Even in this case, however, there is no way to guarantee that recordkeeping would not alter the usual eating habits of the subjects. Also, it may not be feasible to repeat the three-day record often enough to obtain accurate estimates of nutrients such as vitamin A and cholesterol, which show large day-to-day variations.

The food frequency, 24-hour recall, and diet history methods are reported to have good cooperation rates and lower costs than record methods. The reliability and validity of the food frequency method has not been studied extensively; however, a supportable conclusion from the literature is that the food frequency provides descriptive information about dietary patterns but cannot be used to obtain quantitative data on nutrient intake. While the frequency with which various foods are consumed roughly follows the quantity of intake for some nutrients, correlations are too low in heterogeneous populations with varied diets to have predictive value. The food frequency underestimates nutrient intake compared with the diet history and overestimates it compared with 24-hour recalls. Furthermore, the more that specific food items are aggregated into food groups in order to simplify analysis or minimize the time required for the interview, the lower the correspondence between the frequency of consumption and nutrient intake. Food frequencies that do not assess the usual portion sizes of foods as well as the frequency of consumption have even less quantitative value.

Both the 24-hour recall and the diet history methods reportedly have good cooperation rates and low rates of measurement errors when standardized protocols are followed by trained interviewers. Although the 24-hour recall can theoretically take the form of a self-administered questionnaire, the accuracy of both the 24-hour recall and the diet history are improved when interviewers use probes and food models to assist the subject. The cost of the diet history is higher than a 24-hour recall because it generally takes longer to administer and code and requires more highly skilled personnel. These trade-offs must be balanced against reliability and validity considerations. A major question is whether the unit of data analysis in the study will be individuals or groups.

The literature is unanimous in concluding that a 24-hour recall taken at a single point in time cannot be used to characterize the diet of an individual. It can, however, give good approximations of the average intake and the distribution of values in a group. There are two qualifications to this conclusion. First is that, relative to methods such as seven-day food records or diet histories which cover longer periods of time, the 24-hour recall tends to underestimate nutrient intake. Consequently, it will provide an inflated estimate of the proportion of the population with intakes that fall below dietary standards (Hegsted, 1975). Second, persons with low intakes tend to over-report and persons with high intakes tend to under-report in some samples of subjects (Madden et al., 1977; Gersovitz et al., 1978). This so-called flat-slope syndrome reduces the sensitivity of the 24-hour recall in detecting differences in the mean intakes of groups such as participants and nonparticipants in a nutrition intervention program. Cross-sectional studies that use the 24-hour recall to compare group intakes should investigate this phenomenon and make accommodations for it in methods of data analysis or in the level of probability accepted for statistical significance.

The diet history, in comparison with other methods, has been shown to overestimate nutrient intake. It should be noted, however, that none of the studies evaluating the diet history method followed the exact procedures that were originally developed by Burke. In Burke's method, the usual intake obtained for a typical day was cross-checked by a frequency questionnaire and verified by a three-day food record. Nutrient values obtained from the history were used to compare individuals to one another by categorizing their intake of each nutrient according to the RDA. Relating the intakes of individuals to the RDA is not appropriate when only dietary data are analyzed, but Burke designed the rating system so that it could be correlated with biochemical, clinical, and anthropometric findings as well as other data on health status that were obtained in the first step of the history. It appears that the diet history method, including all of the steps originally developed by Burke, is an appropriate method to use as an alternative to food records in longitudinal studies that attempt to discern changes in the nutritional status of individuals.

A final set of conclusions that can be drawn from the literature concerns the use of the various dietary assessment methods to obtain data from children. Evaluations of cooperation, measurement error and accuracy of the various methods using child subjects are based on studies in which the children providing the data were at least nine to ten years of age. Children nine years and older are capable of giving accurate information, regardless of method, as long as the protocols are well standardized and the data collectors are sensitive to the language and developmental maturity of the child. Rapport is especially important with older children, who may not be as willing to cooperate or provide truthful information.

The only methods that have been tested with children under nine years of age are the 24-hour recall and the diet history, but most authors are of the opinion that children of this age are less reliable and accurate. However, the experience in HANES (Youland & Engle, 1976) and the findings of Emmons and Hayes (1973) suggest that mothers may not always be aware of what their children eat, especially away from home. Therefore, data from mothers of young school-age children may be no better than data taken directly from the child. In over 20 years of longitudinal research with children, Beal (1967) found that the best solution when taking dietary histories from children in the primary grades was to interview the mother and child at the same time. The same approach can be recommended for the 24-hour recall.

The literature provides no indication of whether food frequency questionnaires can be successfully administered to children of any age. The ability to respond to the food frequency format requires the child to calculate the number of times per day, week or month that each food is eaten. Young children might have difficulty performing these operations. To avoid the need for calculations, response categories such as "often," "seldom" and "never" can be used. However, the use of these categories limits the analytical power of the information.

Although long lists of food items may be used in a food frequency questionnaire, most forms collapse foods into food groups. The loss of quantitative precision when specific items are collapsed into food groups has already been pointed out. For children, food groups pose an additional problem: in order to respond, children must know the correct groups to which food items belong. Results of a food frequency questionnaire for some children could be more of an indication of their knowledge of conventional food grouping systems than a reflection of their actual food intake.

The advantage usually given for the food frequency is that it provides an indication of dietary patterns or the consumption of foods thought to be associated with chronic disease conditions. In a cross-sectional study, patterns of consumption for the foods of interest can be discerned from the number of times the items are reported in the group. Frequencies in groups such as participants and nonparticipants of school nutrition programs can be compared. In longitudinal studies where the focus is more likely to be on individuals, the same kind of data can be obtained from the diet history. Therefore the food frequency provides no additional information beyond that obtained by the 24-hour recall and diet history methods.

Following data collection, information on food consumption is usually converted to nutrient intake. Although chemical analysis is the most accurate method, values derived from food composition tables are the only practical means of obtaining the information in large-scale field surveys. Computer programs for nutrient analysis are based on data from the U.S. Department of Agriculture, published studies, and food manufacturers. Data for nutrients such as folic acid, magnesium, zinc, copper and vitamin E--and for processed and convenience food items--will vary considerably according to source.

A number of methods can be used to analyze the results of nutrient analysis. Meaningful comparisons of data from groups can be made by comparing the distribution of nutrient intakes in relation to the RDA, although intakes of individuals that fail to meet the RDA cannot necessarily be judged as deficient. Examination of the number of the times various food items containing high amounts of fat, sugar or salt are reported and the nutrient density of the diet can supply additional information about the food patterns of different groups of subjects.

B. *What Biochemical Methods Have Been Used to Assess Nutritional Status and What Are Their Strengths and Weaknesses?*

OVERVIEW

Biochemical measures of nutritional status are tests performed in a hospital, commercial, or other laboratory to determine the levels or activities of nutrients in the body (Christakis, 1973). The tests are performed on biological samples that can be collected from subjects at the laboratory or in the field. Most biochemical tests are performed on samples of blood or urine. Recently, methods that use other kinds of samples such as hair and saliva have been developed.

Not all nutrients can be evaluated by biochemical tests. According to Christakis (1973), biochemical tests are most commonly used to evaluate the status of the following nutrients:

1. protein
2. blood-forming nutrients: iron, folic acid, vitamin B_6 and vitamin B_{12}
3. water-soluble vitamins: thiamin, riboflavin, niacin and ascorbic acid
4. fat-soluble vitamins: A, D, E and K
5. minerals: iodine, trace minerals such as copper and zinc
6. cholesterol, triglycerides, glucose and various enzymes that are implicated in heart disease, diabetes and other chronic diseases.

More than one biochemical test is available for most of these nutrients. The different tests measure different aspects of nutrient metabolism. Depending upon the test that is used, biochemical measures can provide information about an individual's recent dietary intake or more long-term nutritional status. The levels of most nutrients in biological samples fluctuate in a normal range depending on the amounts taken in the diet and the amounts present in body stores. If dietary intake is inadequate over a long enough period of time the levels in the body will decrease. If the dietary deficiency continues, abnormalities will occur in body functions that depend upon the deficient nutrients. Some biochemical tests detect these abnormalities before clinical signs and symptoms appear. These tests are therefore sensitive indicators in the early stages of malnutrition.

Detecting the effects of overconsumption of nutrients by biochemical means is not as straightforward as detecting nutrient deficiencies. The body has several ways of protecting itself from overconsumption. For example, water-soluble vitamins in the body rarely exceed normal limits because excess quantities are excreted in the urine. Fat-soluble vitamins are not excreted, but are removed from the blood and stored in organs such as the liver. These stores cannot be examined without using invasive laboratory methods. The amounts of vitamins naturally present in food are not high enough to reach harmful levels, but toxic amounts can be obtained from large doses of vitamin supplements (see Chapter III).

For some substances, such as iron and cholesterol, there are homeostatic mechanisms that block absorption in the gastrointestinal tract to prevent levels in the body from getting too high. For other substances, such as glucose (sugar) and calcium, levels in the body are under hormonal control. Consequently, when higher-than-normal levels occur, the cause is more likely the result of pathology which alters normal metabolism than of overconsumption *per se*. The relationships between high dietary intake and body levels of some substances (e.g., cholesterol) are not well understood.

Not all of the nutrients listed by Christakis are feasible to study in large-scale field studies. In some cases, samples required for the tests cannot be collected in the field. In other cases, costs of processing samples from large numbers of subjects are prohibitive. Of those tests that are feasible, not all may be required to meet the objectives of the study.

The selection of nutrients to be assessed by biochemical methods for a study of school nutrition program impacts in the United States should be based on results of previous studies and the known prevalence of nutrition problems in the school-age population. Both of these subjects are reviewed in other chapters of this report. Based on conclusions from this review, the assessment of iron status should receive primary consideration. In the following sections of this chapter, the strengths and weaknesses of methods to assess iron nutriture in children and the standards available for data interpretation are discussed in detail.

The biochemical assessment of other nutrients offers less promise of detecting school nutrition program impacts. Nevertheless, brief descriptions of methods of assessing protein, vitamin A, ascorbic acid thiamin, riboflavin, and the trace minerals copper and zinc are provided because these nutrients have been assessed in some of the major studies reviewed in Chapters III and IV. In addition, brief comments are made regarding the assessment of serum cholesterol and other blood lipids in children because of current public interest in this subject. Following these discussions practical aspects of collecting biochemical samples, including cooperation of subjects, procedures and relative costs, are reviewed. All of these factors affect the reliability of biochemical measurements. A detailed explanation of the analytical methods used to analyze samples in the laboratory is beyond the scope of this chapter. However, Table II-3 (from Fomon, 1977) lists analytical methods that are recommended for a number of nutrients. Interested readers are encouraged to pursue the references in this table and others mentioned in the text.

ASSESSMENT OF IRON STATUS

Most health assessments of children include an evaluation of iron status (Fomon, 1977; Sauberlich, 1974; Christakis, 1973; Owen & Lippman, 1977). Iron plays a critical role in the formation of hemoglobin, the pigment in red blood cells. The iron in hemoglobin binds oxygen to transport it through the body to the tissues and cells.

The iron in hemoglobin accounts for approximately 67 percent of the total iron in the body. A second location for iron is in the myoglobin of muscles. The iron in myoglobin also binds oxygen, playing an important role in energy metabolism. Myoglobin contains about 27 percent of the body's iron reserves. Iron is present in small amounts in other body cells as part of enzyme systems that act as co-factors in a variety of chemical reactions. In these enzymes, iron acts variously as a bridge between the enzyme and its

Table II-3. Biochemical Methods and Remarks Regarding Interpretation

Substance	Method	Quantity Required	Comment
Hemoglobin (blood)	Cyanmethemoglobin (O'Brien et al., 1968a)	20 µl	Concentration of hemoglobin less than 11.0 g/100 ml for children below 10 years of age and less than 12.0 g/100 ml for older children (less than 13.0 g/100 ml for males over 14 years of age) indicates anemia (See Part II, Chap. 4).
Hematocrit	Capillary tube (O'Brien et al., 1968b)	40 µl	Hematocrit less than 34 for children below 10 years of age and less than 37 for older children (less than 41 for males over 14 years of age) indicates anemia (see Part II, Chap. 4).
Iron and iron-binding capacity (serum)	Manually by method of Fischer and Price (1964) or automated (Garry and Owen, 1968)	200 µl 100 µl	Concentration of iron, iron-binding capacity and percent saturation of transferrin may require different interpretation in infants than in older individuals (See Part II, Chap. 4).
Free erythrocyte porphyrins (blood)	Method of Piomelli et al. (1976) with filter paper disc	100 µl	Free-erythrocyte porphyrin/hemoglobin ratio greater than 5.5 µg/g indicates iron deficiency.
Total protein (serum)	Microbiuret manually (O'Brien et al., 1968c) or automated (Failing et al., 1970)	50 µl	With manual method, a serum blank is desirable.
Albumin (serum)	Electrophoresis on cellulose acetate (Foman et al., 1970)	10 µl	Concentration of albumin less than 2.9 g/100 µl suggests poor protein nutritional status.
Ascorbic acid (plasma)	2,6 Dichloroindophenol reaction manually (O'Brien et al., 1968d) or automated (Garry et al., 1974)	20 µl 50 µl	Concentration less than 0.3 mg/100 ml suggests that recent dietary intake has been low.
Vitamin A (plasma or serum)	Fluorometry (Garry et al., 1970; or Thompson et al., 1971)	200 µl	Concentration less than µg/100 ml suggests deficiency and concentration less than 20 µg/100 ml indicates low stores.
Alkaline phosphatase (serum)	Liberation of p-nitrophenol manually (O'Brien et al., 1968e) or automated (Morgenstern et al., 1965)	100 µl	Activity greater than 25 Bodansky units/100 ml is suggestive of rickets.
Inorganic phosphorus (serum or plasma)	Modification of method of Fiske and Subba Row (1925) manually (O'Brien et al., 1968f) or automated	50 µl	Concentration less than 4.0 mg/100 ml is abnormal and suggestive of rickets. However, normal concentration does not rule out the presence of rickets.
Urea nitrogen (serum)	Urease manually (O'Brien et al., 1968g) or diacetyl monoxime manually or automated (Marsch et al., 1965)	100 µl 50 µl	Concentration less than 8 mg/100 ml suggests low recent dietary intake of protein. However, concentrations as low as 3.5 mg/100 ml are sometimes found in breastfed infants.
Cholesterol (serum)	Manually by method of Carr and Drekter (1956) or automated (Levine and Zak, 1964)	100 µl	Concentration of cholesterol more than 230 mg/100 ml indicates hypercholesterolemia (See Part II, Chap. 2).
Lipoproteins (serum)	Agarose electrophoresis (Laboratory Methods Committee, 1974)	100 µl	For interpretation, see Fredrickson and Levy (1972).
Creatinine (urine)	Alkaline picrate manually (O'Brien et al., 1968h) or automated	100 µl	Serves as reference for other urine determinations.
Riboflavin (urine)	Fluorometry (Horwitz, 1970a)	2 ml	Excretion less than 250 µg/g of creatinine suggests low recent dietary intake.
Thiamin (urine)	Thiochrome fluorometry (Horwitz, 1970b)	10 ml	Excretion of less than 125 µg/g of creatinine suggests that dietary intake has been low for weeks or months.
Iodine (urine)	Automated ceric ionarsenious acid system (Garry et al., 1973)	5 ml	Excretion of less than 50 µg/gm of creatinine suggests low recent dietary intake.

substrate, a component of the enzyme's active site, or an electron acceptor from the substrate.

In addition to the above forms and functions of iron, several locations act primarily as storage sites and as mechanisms for iron transport. Iron is stored in the bone marrow and in the reticuloendothelial system within the cells as either hemosiderin or ferritin. Some ferritin is also kept in equilibrium with iron circulating in serum. In abnormal states, too much iron, usually in the form of hemosiderin, can be stored in organs such as liver and the lungs. Iron is transported in the body by a protein called transferrin. Normally, about one-third of the available transferrin is saturated with iron.

An insufficient intake of iron can ultimately result in a reduction of iron in all of the body's iron-utilizing components described above. Because of iron's critical role in oxygen transport, impairment of the body's ability to manufacture hemoglobin as the result of a lack of iron could have marked effects on respiration and energy metabolism. Extreme states of deficiency can result in convulsions or cardiac arrest. The body, however, has the ability to make a number of homeostatic adjustments in the face of declining iron stores which permit the continuous delivery of oxygen to the tissues despite a large reduction in hemoglobin mass and number of red blood cells (Leibel, 1977).

Until recently, it was believed that the iron-containing enzymes were impervious to iron deficiency (Woodruff, 1977). It is now known, however, that these enzyme systems can be diminished and possibly exhausted in the early stages of iron deficiency, well before the effects on hemoglobin and red blood cells appear (Leibel, 1977; Woodruff, 1977). The consequences of these deficiencies, with and without accompanying decreases in hemoglobin or red- blood-cell volume, have been reviewed by Leibel (1977). According to several reports, symptoms such as irritability, fatigue, weakness and dysphoria are produced by iron deficiency and can be rapidly improved following iron therapy.

Other investigations have attempted to correlate iron deficiency with learning disorders. Howell (1971), for example, described decreased attentiveness, narrow attention span and perceptual restrictions in three- to five-year-old children with reduced hemoglobin values. Sulzer et al. (1973) found that a group of Head Start children with low hemoglobin values had lower scores on intelligence and vocabulary tests than children with normal hemoglobin values. Webb and Oski (1973) studied 12- to 14-year-old junior high school students from a predominantly black, economically-deprived community and found associations between hemoglobin levels and the vocabulary, reading, arithmetic and problem solving components of the Iowa Test of Basic Skills.

Leibel (1977) points out that the findings of these studies are unlikely to be due to a reduction in hemoglobin, *per se*, because similar impairments are not observed in other conditions (such as sickle-cell anemia and thalassemia) where hemoglobin mass is also reduced. Leibel suggests that the symptoms are the results of effects on the central nervous system caused by the reduction of the iron-containing enzymes. His assertion is backed by a number of studies which show that laboratory animals with only mild iron deficits exhibit behavioral abnormalities similar to those described in the studies of children. The abnormalities can be corrected in these animals within a few days after iron therapy (Glaver & Jacobs, 1972). These studies highlight the importance of measuring the status of iron nutriture in the school-age population. They also emphasize the point made by a number of authors that measures of hemoglobin or red cell mass alone do not provide a complete picture of iron status (Sauberlich et al., 1974; Christakis, 1973; Fomon, 1977; Owen & Lippman, 1977).

Measurements of Iron Deficiency

Measurements of iron deficiency can be performed by determining the concentration of hemoglobin in red blood cells or the packed red cell volume (hematocrit), mean corpuscular volume (MCV), tranferrin saturation, serum iron, free erythrocyte protoporphrin and serum ferritin. All of these measures are performed on samples of blood. It is also possible to assess iron stores by aspiration of bone marrow, but this invasive method cannot be used in surveys.

Hemoglobin. Hemoglobin concentrations in blood samples are measured in grams per deciliter (g/dl). The concentration is measured by a device called a spectrophotometer after the blood sample has been diluted in a solution that converts hemoglobin to cyanomethemoglobin (Cartwright, 1968). A simpler procedure is to measure the amounts visually, but the results of this method are less reproducible (Dallman et al., 1980).

Hemoglobin levels can be affected by other conditions besides iron deficiency. For example, hemoglobin will be reduced in megaloblastic anemia caused by folic acid or vitamin B_{12} deficiencies (Sauberlich, 1974). Chronic infection and acute blood loss can also result in decreased hemoglobin levels. Hemoglobin levels will also drop in sickle-cell anemia and in thalassemia minor--a condition that is common among blacks and people from the Mediterranean and Southeast Asia. In children, however, iron deficiency is usually the cause of low hemoglobin levels (Woodruff, 1977).

Values of hemoglobin that fall below 11 g/dl for children under ten years, 12 g/dl for children aged 10 to 14, and 13 g/dl for males over 14 are considered evidence of anemia (Fomon, 1977). Percentile curves for hemoglobin in infancy and childhood have been published by Dallman and Siimes (1979). These curves were derived from several populations of white children living near sea level. In all but one group, subjects were excluded if additional laboratory data gave presumptive evidence of iron deficiency.

According to Cook and Finch (1979), hemoglobin alone is unsuitable as a screening method for detecting iron deficiency. The level of circulating hemoglobin shows wide variations in normal subjects. Data from Dallman and Siimes (1979) indicate that hemoglobin concentrations in childhood increase approximately .5 g/dl from one age range to the next. In the health screening of infants and children, an error of .5 g/dl can result in 10 percent of normal individuals being incorrectly categorized as anemic.

There is growing evidence that the standards currently used to evaluate hemoglobin may not be applicable to all population groups. All three of the national surveys of nutritional status (Ten State Nutrition Survey, Preschool Nutrition Survey, and HANES) have discovered that black people of all ages have hemoglobin values that average .5 to 1.0 g/dl lower than white individuals, even when the subjects are matched for income (Garn & Clark, 1976). Local studies have shown similar results. In a study of over 4,000 children in Bogalusa, Louisiana, the mean difference in hemoglobin between blacks and whites was .64 g/dl (Frerichs et al., 1977). Dallman et al. (1978) studied data from multiphasic exams given to 1,718 white, 741 black and 315 Oriental children in California. All were healthy and non-indigent. The median hemoglobin for blacks was .5 g/dl lower than the median for both white and Oriental children. This difference persisted after excluding children with abnormal hemoglobins and hematocrits of 5 percent or more below the normal mean for age. Dallman et al. (1980) maintain that failure to adjust hemoglobin standards downward by about .5 g/dl for blacks could result in falsely identifying about 10 percent of the normal black population as anemic.

Hematocrit. The hematocrit is a measure of the volume of packed red blood cells. If iron is insufficient to produce hemoglobin for red cell synthesis, the volume of packed red cells in a given quantity of blood will be reduced.

The hematocrit is determined by spinning the blood sample in a centrifuge for about one minute (Cartwright, 1968). The centrifugal force packs the red cells at the bottom of the test tube. The hematocrit is calculated by measuring the height of the column of red blood cells as a percentage of the height of the entire column of red blood cells and plasma (Dallman, 1980). Values below 34 percent for children under 10 years, 37 percent for children 10 to 14 years, 41 percent for males over 14 years, and 37 percent for females over 14 years are considered diagnostic of anemia (Fomon, 1977).

According to Dallman et al. (1980), there is uncertainty whether the hematocrit is a sensitive indicator of iron deficiency. Data from the Center for Disease Control (1977) indicate that almost three times more one to two year olds have low hemoglobins than would be predicted on the basis of hematocrits alone. The potential for under-reporting anemia from hematocrit levels makes it desirable to use this measure only in combination with other more reliable tests.

Mean Corpuscular Volume (MCV). Mean corpuscular volume is a measure of the total volume of red cells in the body. As with the hematocrit, the insufficiency of iron to produce red cells will cause the MCV to be reduced.

Formerly, the measurement of MCV was time-consuming and unreliable because it was derived from the ratio of the hematocrit to the number of red cells, which was obtained by visual counts through a microscope (Dallman et al., 1980). The availability of electronic counters has made the procedure more accurate. Reference values for MCV for infants and children have been published by Dallman and Siimes (1978). The data are drawn from the same population as was used to derive the hemoglobin curves. The percentile curves illustrate slight differences in values between boys and girls. Although low MCV is most commonly associated with iron deficiency, it can also result from thalassemia minor. Since hemoglobin is also reduced by this condition, the two tests in combination will not necessarily rule out the possibility of confusion.

While MCV has been used to measure the extent of anemia in clinical studies, it is not usually performed in large surveys. Neither the Ten State Survey or HANES assessed MCV. The method is limited by the availability of the electronic counter or the expense incurred if it must be purchased for the survey.

Serum Iron and Transferrin Saturation. Hemoglobin, hematocrit and MCV do not give indications of iron reserves. Traditionally, tests of serum iron or transferrin saturation have been recommended as a way of supplementing the information obtained from hemoglobins and hematocrits (Fomon, 1977; Christakis, 1973). The amounts of serum iron and transferrin in blood samples are both measured by a spectrophotometer. The use of automated techniques yields highly reproducible results according to Giovaniello et al. (1968). The tranferrin saturation is calculated by dividing the concentration of serum iron by the total amount of transferrin and multiplying by 100 to express the factor as a percentage (Dallman et al., 1980). A serum-iron of 50 g/dl and transferrin saturation of 16 percent are used as cutoff points for diagnosis of iron deficiency in children 6 to 12 years of age (Christakis, 1973). Dallman et al. (1980) point out that there are large variations in serum iron that result in many false-positive and false-negative diagnoses when either serum iron or transferrin saturation are the only tests used to determine iron deficiency. For example, Swartz and Baehner (1968) discovered diurnal variation in serum iron after three years of age. Values are usually higher in the morning than at night. Transferrin saturation can also be affected by inflammatory diseases (Cartwright & Lee, 1968), and is reduced in protein-calorie malnutrition (Sauberlich et al., 1974).

Free Erythrocyte Protoporphrin (FEP). Protoporphrin is a compound that is used to form the heme portion of the hemoglobin molecule. If iron is deficient, less hemoglobin will be formed. Therefore, the amount of free erythrocyte protoporphrin that is not used to form hemoglobin will increase.

FEP is measured using a fluorometer or another instrument specifically designed to assess directly the amount of FEP in a sample of blood (Blumberg et al., 1977). The instrument is being used more frequently in health clinics because, in addition to iron deficiency, FEP can be used to screen children for lead poisoning.

According to Cook et al. (1976), FEP will identify approximately twice as many iron-deficient subjects as can be identified by hemoglobin determinations. However, FEP is not a good measure of iron stores, since it will remain normal until almost all of the body's iron stores are depleted.

Serum Ferritin. The measurement of serum ferritin has recently gained prominence as the preferred technique for determining iron stores. According to Woodruff (1977), serum ferritin "has proved to be a most precise method for estimating iron stores and may prove to be a definitive measurement of biochemical iron deficiency." Koerper and Dallman (1977) explain that the first phase of iron deficiency occurs when ferritin stores are reduced, resulting in decreased amounts of serum ferritin. The second phase occurs when serum iron and iron-binding capacity are reduced. There may be little overlap between the first and second phases; Koerper and Dallman (1977) found that most children with low serum ferritin had normal levels of serum iron and transferrin saturation. Thus, a serum ferritin test can detect the problem earlier than any other test.

Serum ferritin is measured by a technique called radioimmunoassay (Addison et al., 1971; Miles et al., 1974). This technique uses radioactive materials that are measured in a gamma radiation counter.

Serum ferritin concentrations vary with sex and show developmental changes with age; however, levels below 10 or 12 micrograms per liter indicate depletion of iron reserves at all ages (Dallman et al., 1980). Lipschitz et al. (1974) warn that serum ferritin is affected by inflammatory diseases. When such a condition coexists with iron deficiency, the two effects may counterbalance one another so that serum ferritin may be in the normal range.

Selection of Measures

Dallman et al. (1980) have discussed the selection of laboratory tests to determine the prevalence of iron deficiency in population surveys. They suggest that hemoglobin and MCV constitute an excellent combination when centralized laboratory facilities are available to handle large numbers of samples with instruments that can be used for both assays. Serum ferritin, as a third test, adds the advantage of being able to measure iron reserves. Alternatives to serum ferritin are transferrin saturation and free-erythrocyte protoporphryn (FEP).

Cook et al. (1976) suggest that the best parameter to use depends on the basal iron status of the population. In populations where iron deficiency is highly prevalent, the critical measure is hemoglobin, although other tests may also be needed to establish that the anemia is due to iron deficiency. When the population is relatively replete with iron, serum ferritin will monitor the largest segment of the population and is, therefore, the most useful measure. In both populations, transferrin saturation and FEP enhance the estimates at the intermediate levels of iron deficiency. Cook et al. believe that there is a strong argument for including all four measures of iron status in population surveys.

Securing enough blood for all four tests would require venipuncture. If a fingerstick is the only practical alternative, the assessment will probably be limited to a single test. Given the general iron status in the school-age population in the United States, the parameter most sensitive to nutrition program impacts would be iron stores. Serum ferritin is the method of choice, but the cost and availability of the assay methods could limit its feasibility in a large-scale field study.

Of the measures commonly used to diagnose the second stage of iron deficiency, transferrin saturation is the preferred method. The procedure requires venous blood, however, and problems in interpreting results make it undesirable to use tranferrin saturation alone.

Hemoglobin and/or hematocrits are well standardized tests that can be run from fingerstick blood. A diagnosis based on hemoglobin alone is likely to yield a high number of false-positive and false-negative findings. Even in conjunction with hematocrits, other causes of reduced hemoglobin, such as sickle-cell anemia and thalassemia minor, cannot be ruled out. Previous studies of school nutrition program impacts have failed to show significant differences in hemoglobin or hematocrit values between participants and nonparticipants, even when the investigation has focused on high-risk groups (Price et al., 1975; Page, 1972; Lieberman et al., 1976).

Discussion

Prior studies of school nutrition programs and studies of nutrition problems of school-age children suggest that the assessment of iron status deserves primary consideration in the evaluation of potential program impacts.

Iron can be evaluated by several different measures, each of which reflects a different stage of iron deficiency. Some investigators (e.g., Cook et al., 1976) believe that all of the measures should be used in population surveys;

however, due to the cost and availability of equipment, this may not be possible. If a limited number of measures can be taken, selection should be based on the iron status of the population.

Given this guideline, the most sensitive measure for school-age children in the United States would be serum ferritin. This measure provides the best indication of iron stores (Woodruff, 1977; Koerper & Dallman, 1977), but the assessment requires specialized and expensive equipment (Dallman et al., 1980).

Hemoglobin and hematocrit measures are frequently performed in child nutrition surveys. These are well standardized tests, but they have several limitations. Both measures may be reduced from conditions other than iron deficiency (Dallman et al., 1980). Current standards used to judge iron deficiency do not account for the fact that hemoglobin levels of black persons are approximately .5 g/dl lower than hemoglobin levels of white persons (Garn & Clark, 1976; Frerichs et al., 1977; Dallman et al., 1978). The hematocrit tends to under-report the extent of anemia in the population (Center for Disease Control, 1977). Consequently, some investigators believe that these two measures alone do not give adequate evidence of iron status (Cook & Finch, 1979; Dallman et al., 1980).

ASSESSMENT OF OTHER NUTRIENTS

In addition to iron, various other nutrients may be of interest in the evaluation of the nutritional impacts of school nutrition programs, depending on the population being studied. The studies reviewed in Chapter III suggest that deficiencies of protein, vitamin A, ascorbic acid, thiamin, riboflavin and trace minerals are not widespread among American children, but they may be of concern for certain subgroups. The functions of these nutrients and the consequences of deficiencies are discussed in Chapter III. A brief summary of methods for evaluating their status in school-age children is given below.

Protein

Protein status is usually measured in surveys by the amount of albumin or total protein in blood serum. Standards for children are available from HANES and the Ten State Nutrition Survey.

According to Sandstead and Pearson (1976), serum albumin and total protein are relatively insensitive measures of protein status for both individuals and population groups. Both measures are affected by a number of conditions that are unrelated to nutrition. In the absence of these conditions, serum protein levels will be maintained for a long period of time despite low protein intake.

Protein status can also be evaluated from hair samples (Nutrition Reviews, 1971). Early studies examining the appearance of hair from children suffering from protein-calorie malnutrition have shown that hair growth ceases almost completely and the diameter of the hair root bulb is reduced. These findings are related more to the duration of malnutrition than to the severity of the protein deficit. More recent studies have attempted to measure the actual amount of protein in the hair root by chemical analysis. These studies have shown that evaluation of hair root protein can be reduced in subjects suspected of having malnutrition even when serum albumin levels are normal. These findings suggest that evaluation of hair root protein may prove useful in the detection of borderline undernutrition in affluent societies, such as the United States, where protein deficiency is not generally considered a problem (Nutrition Reviews, 1971). Nevertheless, hair root protein has not been assessed to date in any of the large-scale nutrition surveys.

There are also tests of protein nutriture using urine samples. These include the urinary creatinine-height index, the urinary hydroxyproline index and the urinary creatinine-urea ratio. The principles of these tests have been described by Sauberlich et al. (1974). Although they have been used in clinical studies and in field studies in developing countries, they have not been used in large-scale surveys in the United States.

Vitamin A

Pearson (1962) states that for practical purposes there are only two biochemical tests of vitamin A status for population studies. These are serum vitamin A and carotene determinations. Carotene is a yellow-orange water-soluble pigment that can be converted to vitamin A in the body. Both serum vitamin A and carotene determinations were made in the Ten State Nutrition Survey and HANES.

Serum vitamin A values are not affected by short-term dietary intake. They represent more long-term status and are affected only when vitamin A stores are reduced. Since the liver appears to have a remarkable capacity to store vitamin A, persons may have low intakes of vitamin A for quite some time before serum levels are reduced. Serum vitamin A is also affected by protein deficiency and a number of non-dietary factors (Pearson, 1962).

The standards used to evaluate serum vitamin A assume that there are no differences by sex or age of subjects; however, findings of HANES showed a steady increase in serum vitamin A values with age. This suggests that different standards may be needed for children and adults.

Serum carotene is a measure of recent dietary intake. Levels will fluctuate daily, depending on amounts of carotene consumed in the diet. As was shown in the previous section, vitamin A intake, which is largely derived from carotene in the United States, is subject to large intraindividual

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variations. Serum carotene will reflect these variations, making it difficult to obtain a reliable measure.

Because serum carotene fluctuates with recent intake it is not as good a measure of vitamin A stores as serum vitamin A. A person could have little carotene in the serum, and yet have adequate vitamin A stores. When carotene is present, it is not possible to distinguish between beta-carotene, the most biologically active form, and other carotene compounds; serum carotene values, therefore, tend to overestimate the amount of beta-carotene that is available (Sauberlich et al., 1974).

Ascorbic Acid (Vitamin C)

Ascorbic acid in field surveys is usually assessed by plasma or serum concentrations. Within a limited range, serum (or plasma) levels of ascorbic acid have a linear relationship with dietary intake. When dietary intake is inadequate, serum levels of vitamin C decrease rapidly. Higher serum levels of ascorbic acid occur temporarily following ingestion of a large dose; however, since the vitamin is water-soluble, excessively high intakes will be excreted in the urine after a plateau is reached in the serum level (Sauberlich et al., 1974).

Large amounts of ascorbic acid are not stored in the body, but the tissues do contain some reserves. The serum level of ascorbic acid is not a good indicator of these reserves. Pearson (1962) reports that when serum levels are at zero, tissue stores could be anywhere from zero to 50 percent. The amount of ascorbic acid in white blood cells is a better indication of tissue reserves, but the measurement is technically difficult and not feasible in field surveys (Pearson, 1962; Sauberlich et al., 1974).

Ascorbic acid can also be measured by urinary excretion. Pearson (1962) claims that this measure provides no more information than serum or plasma levels and is, moreover, complicated by problems of collecting urine samples. However, since urinary excretion and plasma levels of an individual should correspond, the two tests can serve as reliability checks for one another.

The standards for serum (or plasma) ascorbic acid used in the Ten State Nutrition Survey and HANES are not differentiated by age or sex.

Thiamin and Riboflavin

Both thiamin and riboflavin are water-soluble B vitamins. They are usually assessed by urinary excretion in large-scale field surveys (Christakis, 1973). The amounts excreted in urine are correlated with recent dietary intake but are also affected by other factors. For example, riboflavin excretion is influenced by fasting, sleep and exercise (Sauberich et al., 1974).

Amounts of thiamin and riboflavin in the urine are measured either by fluorometric or microbiological methods. The fluorometric method measures amounts of the vitamin present according to the fluorescence given off by the chemical compounds. The microbiological method measures the amounts of the vitamin present according to the growth of micro-organisms supported by a medium containing the sample. According to Sauberlich et al. (1974), both methods are well standardized and yield reliable results. However, there are certain limitations when the methods are used with children in surveys.

Because it is usually impossible to collect 24-hour urine samples in surveys, the amount of thiamin and riboflavin in a random sample taken during the day may not accurately reflect the total 24-hour excretion. To stabilize the measurement, the amounts of thiamin and riboflavin excreted in the random sample are usually expressed in relation to the amount of creatinine that is excreted simultaneously. Creatinine is derived from protein. Its excretion is assumed to be fairly constant throughout the day because it is related to total body size. Relating thiamin and riboflavin to creatinine excretion permits extrapolations from a random sample to a 24-hour specimen. Studies by Pearson (1962) have shown that children normally have higher ratios of urinary thiamin to creatinine than adults, so that adult standards are inappropriate for children. There is very limited information on normal urinary excretion levels of thiamin in children (Sauberlich et al., 1974). Pearson has developed the standards that are commonly used, but according to Sauberlich et al. (1974), these values are estimates based on a sliding scale for age and may need to be revised as more data from surveys became available.

The standards for interpreting urinary riboflavin in children are also based on limited data for normal excretion in children. Data from the Ten State Nutrition Survey appear to validate the standards established by Pearson, but the comparisons were made only for white populations in high-income-ratio states (Sauberlich et al., 1974). There is little information about the applicability of these standards to non-whites.

Recent investigations have also led researchers to question whether the excretion of creatinine is as constant throughout the day as is usually assumed. This in turn has raised questions about whether relating thiamin and riboflavin excretion to creatinine excretion permits a valid extrapolation for a 24-hour period. Sauberlich et al. (1974) state that the method still permits valid estimates for population groups but does not permit valid estimates for individuals. These authors recommend that 24-hour urine samples be collected when evaluating individuals and that the findings from urinary excretion be confirmed by other tests of thiamin and riboflavin status.

The two tests recommended are the transketolase test for thiamin and the glutathione reductase test for riboflavin. Transketolase and glutathione reductase are enzymes involved with energy production in the body which are dependent on thiamin and riboflavin respectively. When the vitamins are

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deficient, the activity of these enzymes is reduced. Because these tests measure functional activity and not simply the amounts of thiamin and riboflavin present, they are more sensitive indicators of nutritional status than urinary excretion. However, both tests require blood samples. To date, the tests have not been performed in large-scale surveys due to the cost of the analytical procedures and the feasibility of processing large numbers of samples.

Trace Minerals

A number of minerals, known to be required in very small quantities to maintain health, have received increasing attention in child nutrition surveys in recent years. Of these so-called "trace" minerals, copper and zinc have been studied to the greatest extent. There are indications (see Chapter III) that these nutrients may be inadequate in some subgroups of the U.S. population. These findings are from local surveys. Copper and zinc status have not been evaluated in a nationally representative sample of U.S. children.

A number of methods can be used to evaluate copper and zinc status. Serum levels are considered the most valid indicators, but "normal" levels in the various blood components are not well established (Sauberlich et al., 1974).

Newer methods being explored for the assessment of copper and zinc use samples of hair and saliva. These have the advantage over blood samples of being non-invasive and easier to collect in field surveys.

The levels of copper and zinc in hair are believed to reflect long-term nutritional status rather than short-term dietary intake. However, Hambidge (1976) has pointed out that the concentration of zinc in hair depends upon the rate of hair growth as well as the delivery of zinc to the root. The hair-zinc concentrations of two groups can only be compared when it is known

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that the mean rate of hair growth is comparable in both. Solomons (1979) adds that since zinc deficiency itself may impair hair growth, hair zinc may not be an accurate estimate of nutritional status.

It has been demonstrated by Hambidge (1973) that the concentration of copper in the hair shaft increases progressively with distance from the scalp. This suggests that exposure to environmental copper is a contaminating factor. Klevay (1974) has also questioned the use of hair samples as a reliable index of copper status in humans. McBear et al. (1971) have questioned the reliability of hair as an indicator of body zinc stores in prepubescent children.

The clinical significance of low levels of zinc and copper in hair is unknown. According to Sandstead (1976), clinical signs appear only with extreme zinc deficiency, which will rarely be found for school-age children in the United States. In the study by Greger et al., poor correlations were obtained between hair values and the dietary intake. Although dietary intake averaged between 60 and 75 percent of the RDA for zinc, only 2 percent of the children had low zinc values in their hair samples. The prevalence of low values for copper was 3 percent.

According to Sauberlich et al. (1974), hair analysis as an index of nutritional status is still in the exploratory stage. Normal values for particular nutrients are not well defined, nor are there established standards for children.

Use of saliva to assess the zinc status of human subjects has been recommended by Henkin et al. (1975). Greger and Sickles (1979) have evaluated changes in salivary zinc in relation to moderate changes in dietary zinc levels and have tested the usefulness of salivary zinc analysis in survey conditions with adolescent females. They found that the collection of saliva is a quick and relatively simple procedure in the field, but adequate precautions must be taken to prevent contamination of the samples. The results of the study showed that zinc in the saliva was sensitive to small dietary changes even though there were no significant correlations between any of the zinc parameters and hair zinc levels. The investigators concluded that salivary zinc has potential as a useful indicator of zinc status, but that a variety of studies are needed before salivary zinc levels can be used in surveys.

Discussion

Biochemical tests for the assessment of protein, vitamin A, ascorbic acid, thiamin, riboflavin and trace minerals such as copper and zinc were reviewed in this section. Several different tests are available for each of these nutrients, but serum or urinary excretion levels are assessed most commonly in field surveys. Serum albumin or total protein and serum vitamin A measure long-term nutritional status. Serum ascorbic acid reflects more recent intake. Urinary thiamin and riboflavin are also correlated with recent intake.

Protein and the status of copper and zinc can also be assessed from hair samples. Hair root protein is potentially a good indicator because it shows evidence of protein deficiency before serum levels are reduced (Nutrition Reviews, 1971), but it has not been used in large U.S. surveys. Use of hair and saliva for the assessment of trace minerals is still largely experimental (Sauberlich et al., 1974). No standards are currently available for interpreting results in children.

ASSESSMENTS ASSOCIATED WITH EXCESSIVE INTAKES OF DIETARY CONSTITUENTS

Fat and Cholesterol

High levels of fat and cholesterol in the diet have been associated with a high incidence of cardiovascular disease in a number of population studies. These studies have been conducted mainly on adults. One of the identified risk factors for cardiovascular disease is a high level of serum cholesterol. Since pathogenic studies suggest that cardiovascular disease begins in childhood, some authorities are of the opinion that dietary intervention to control serum cholesterol should begin at an early age (Fomon, 1977). Measurement of cholesterol and other serum lipids in children is a clinical screening and diagnostic procedure for cardiovascular risk, but is not a measure of nutritional status *per se*. Presently, direct relationships between dietary intake of fat and cholesterol and their levels in the blood have not been established. Several studies currently in progress are attempting to clarify these relationships in children (Berenson, 1980).

Cholesterol levels greater than 230 milligrams per 100 milliliters are usually considered evidence of hypercholesterolemia (high blood cholesterol) in children (Fomon, 1977). When children with high serum cholesterol levels are identified, triglyceride and lipoprotein profiles should be obtained from the children and their families. These profiles detect abnormal levels of the various compounds that transport fat and cholesterol in the body. Abnormal levels in children are usually of genetic origin. These children require treatment with a special dietary regimen.

The measurement of total serum cholesterol is a fairly well standardized procedure (Fomon, 1977), but continued research is needed on ways to estimate serum triglycerides and lipoproteins in children. According to Berenson (1980), these blood constituents are more sensitive indicators of lipid abnormalities than total serum cholesterol; however, methods to evaluate them are available only in specialized laboratories.

Sugar

Excessive consumption of sugar in children is of concern because of the possible role it plays in the etiology of obesity, diabetes and dental caries. There is no biochemical method that measures sugar as a parameter of nutritional status. Sugar, as glucose, is the primary source of energy for the body's cells. Body metabolism, through the mediation of hormones, is directed toward providing a constant supply of glucose to the cells in the face of fluctuating intakes of dietary carbohydrates. Blood glucose levels, therefore, reflect immediate dietary intake and adequacy of hormone levels. A high level of sugar in the blood is diagnostic of disorders of carbohydrate metabolism, and cannot be used as an indication of excessive carbohydrate intake in normal individuals. Similarly, the presence of sugar (glucose) in the urine indicates abnormal metabolism, not dietary or nutritional status. These tests, therefore, should be used only as screening tools to assess the prevalence of carbohydrate disorders in the population.

Discussion

A comprehensive discussion of the relationship of dietary factors such as cholesterol, fat and sugar to the development of cardiovascular and other chronic diseases in children is beyond the scope of this review. Consequently, biochemical methods to assess levels of these constituents in the body have been only briefly described. Procedures for measuring serum cholesterol are well established, but methods to assess triglyceride levels and serum lipoproteins in children require further research (Berenson, 1980). There is no available biochemical method to assess the effects of excessive sugar consumption.

COLLECTION OF BIOLOGICAL SAMPLES

The selection of biochemical measures, the successful collection of samples in the field, and the accurate processing of data require investigators to consider practical aspects of survey design such as cooperation of subjects, field and laboratory procedures, and personnel and other costs. Although the specifics of each of these factors differ with each test, there are some general guidelines that apply to all of them.

Cooperation of Subjects

Although there is very little literature assessing cooperation rates of subjects with biochemical field studies, it is the opinion of most authorities that the potential for refusing to participate is greater when biochemical data are collected than when only dietary or anthropometric information is obtained (Burke & Pao, 1976). In studies of school nutrition program impacts, permission to collect samples must be secured from the subjects themselves, their parents and school authorities. Because of the legal implications involved, particularly with the collection of blood, permission may be difficult to obtain when the study is expected to draw subjects from a number of different school districts in several different states.

Urine Samples. The tests using urine samples are based on correlations between the sufficiency of intake of the various nutrients and their concentrations in the urine. Because the concentrations vary throughout the day due to the different volumes of urine people excrete, the most valid estimate is obtained when subjects collect samples over the entire 24-hour period. This degree of cooperation cannot be expected in surveys involving large numbers of subjects.

Most surveys request subjects to provide a "casual" or random sample when they come to the examination center. Collection of these samples means that subjects must have access to lavatories. Embarrassment may still cause subjects to refuse to cooperate. In the study of school-level impacts of nutrition programs in Washington State, parents readily gave permission for investigators to collect urine samples from their children, but more children themselves refused to give urine samples than refused to give blood samples (Price et al., 1975).

Blood Samples. The quantity of blood required for biochemical assessments depends upon the number of tests to be performed. Table II-3 shows how much blood is required for each of the recommended procedures.

Blood may be drawn by fingerstick or by venipuncture. Only a small amount (.5 ml) of blood can be obtained from a fingerstick. When greater quantities of blood are required, the only alternative is venipuncture.

Most authorities believe that venipunture is no more painful than a fingerstick (Dallman et al., 1980), but the procedure may be more threatening to children. In the Washington State Survey, only 5 percent of the children refused to give blood samples. However, it was not always possible to obtain the four vacutainers of blood called for by the protocol (Price et al., 1975).

Other Samples. Collection of other biological samples such as hair and saliva are generally not as painful as the collection of blood samples and are not embarrassing for the subjects. There is no information in the literature indicating how well children cooperate with these procedures.

Collection Procedures

Guidelines for collecting biological samples and preserving them for analysis have been provided by Christakis (1973), Dallman et al. (1980), and others. In this section, emphasis is given to samples of urine and blood. Attention must be given to how these specimins are collected, preserved and transported in order to make sure the nutrients to be assessed are not destroyed.

Urine Samples. Urine samples are often collected to assess ascorbic acid and B vitamins such as thiamin and riboflavin. These nutrients are easily degraded by heat, air and light. Urine samples must be acidified and kept away from direct light in order to protect these nutrients. If analysis is not performed on site, it is recommended that urine samples be chilled during shipment to the laboratory (ICNND, 1963).

Blood Samples. The procedure for taking blood samples from a fingerstick are relatively simple (Dallman, 1980). The major problem to avoid is contamination of the sample with tissue fluid. This can happen if the finger is squeezed to encourage blood flow. Blood from the fingerstick can be collected directly into heparinized containers that can be used with analytical equipment on site or shipped to the laboratory. The heparin prevents the blood sample from clotting.

Blood drawn from veins can be obtained from the arms of children. Some tests (e.g., serum cholesterol) are more accurate when samples are obtained from fasting subjects.

When working with young children, two persons are usually required for the venipuncture--one person positions the child while the other draws the blood. Children may be less frightened if they are encouraged not to look at the needle as it is inserted in the arm. It is sometimes difficult to find a vein in children. In the Bogalusa Heart Study, only two attempts at venipuncture were allowed (Berenson, 1980).

Depending on the tests to be performed, blood samples may be either clotted or treated with an anticoagulant. Clotted samples are usually centrifuged on site to separate the serum.

Christakis (1973) recommends that as much as possible of the sample preparation, including chilling and/or freezing, should be done immediately at the collection site. The procedures to follow depend upon the tests that will be made. Therefore, it is imperative to review each analytic technique carefully prior to the survey to assure that the appropriate precautions are taken.

Most samples that cannot be analyzed on site need to be frozen for shipment to the laboratory. The usual procedure is to pack the samples in dry ice. The dry ice pack will keep samples frozen for 60 to 72 hours (Christakis, 1973).

RELIABILITY OF LABORATORY TESTS

Although intraindividual variation occurs in biological samples, greater sources of error result from the selection, maintenance and use of laboratory equipment. The Center for Disease Control (1979) has prepared a review of selected hematological instruments used in nutritional assessments. The review states that there is a greater potential for measurement error when instruments capable of doing more than one test are used for a specific test. This is primarily true for instruments designed to perform hemoglobin determinations. Other equipment, such as spectrophotometers, can be used reliably for a variety of laboratory assessments.

Christakis (1973) says that a crucial need in laboratory nutritional assessment is a coordinated program to standardize the various tests. This is especially important when several different laboratories are engaged to process the samples. For the routine laboratory tests there are standards, calibrators, and plasma or serum controls available for laboratories to use in checking the accuracy of their analytic procedures, but these do not exist for all nutritional evaluation techniques. In the absence of such standards, Christakis recommends that analytical values obtained from the laboratory involved with the survey be compared with values obtained from replicate samples submitted to a standard referencing laboratory.

COST OF BIOCHEMICAL MEASURES

Personnel and equipment constitute the major costs in the biochemical assessment of nutritional status. Collection of blood samples requires more highly skilled personnel than collection of urine, saliva and hair. Dallman et al. (1980) state that health workers with relatively little experience can be trained in the procedure for obtaining blood from a fingerstick. Taking blood by venipuncture requires more experience and, in some states, the technicians must be licenced. Persons licensed to draw blood include registered nurses and medical technologists.

Training costs depend upon the expertise of personnel. Even skilled professionals require some training to acquaint them with the study and to assure standardization of procedures. Less experienced personnel must also be trained in proper sample collection techniques.

The costs of the tests themselves vary from less than one dollar per subject for a hematocrit determination to several hundred dollars for tests requiring use of highly technical analytical equipment. These costs depend upon the number of subjects in the study, the number of tests run, the number of duplicates required to check reliability, and whether new equipment must be purchased for the study. If a central laboratory is used for analysis, packaging and shipment costs for the samples must also be considered.

CONCLUSIONS

Biochemical analyses of blood, urine, hair and saliva samples provide evidence of nutrient levels and activities in the body with varying degrees of precision. Not all measures are suited to large-scale field studies. Of those tests commonly performed in surveys, the assessment of iron status is performed most often. The assessment of protein, vitamin A, ascorbic acid, thiamin, riboflavin, and trace minerals such as copper and zinc have also been of interest in recent child nutrition surveys and studies of school nutrition impacts. Although there is much public interest in measures such as serum cholesterol and other blood lipids, the relationships between these factors and dietary intake in children are unclear. Further research is required to determine whether biochemical assessments of serum cholesterol and other lipids can provide indications of school nutrition program impacts.

The measures available to assess iron status in children include hemoglobin, hematocrit, mean corpuscular volume (MCV), serum iron and transferrin saturation, free-erythrocyte protoporphrin (FEP) and serum ferritin. Each of these tests measures a different stage of iron deficiency. Most authorities believe that more than one test is required to assess the prevalence of iron deficiency in a population (Cook et al., 1976; Dallman, 1980). However, this may not be feasible in large-scale field surveys. If only one measure can be taken, serum ferritin should be the measure of choice. Serum ferritin is the best measure of iron stores (Woodruff, 1977; Koerper & Dallman, 1977). Considering the prevalence and severity of iron deficiency in the U.S. population of school-age children, it is likely that iron stores would be the most sensitive indicator of school nutrition program impacts. A disadvantage of the serum ferritin measure is that it requires expensive equipment for analysis of blood samples. The measure has not been used in large-scale surveys.

Most field studies assess iron status using either hemoglobin or hematocrit determinations. These measures are relatively inexpensive and well standardized. The disadvantages are that the measures are affected only in the later stages of iron deficiency and are influenced by other conditions. The hematocrit in particular is subject to producing false-negative results (Center for Disease Control, 1977). Hemoglobin is also limited by the fact that current standards may not be applicable to black children (Dallman et al., 1980).

Protein, vitamin A, ascorbic acid, thiamin, riboflavin, and trace minerals are usually measured by serum or urinary excretion levels. Other samples, such as hair and saliva, can be used, but the techniques and the interpretation of findings are not well standardized (Sauberlich, 1974).

The biggest drawback of all biochemical methods is their inconvenience for the subjects and the strong possibility that permission to collect samples will not be obtained from the subjects, their parents or school authorities. Depending on the tests selected, personnel costs and costs of processing large numbers of samples can also be considerable. Studies considering the use of biochemical methods to determine impacts of school nutrition programs must balance these limitations against the likelihood of showing effects, based on findings from previous research.

C. *What Clinical-Anthropometric Measures Have Been Used to Assess Nutritional Status and What Are Their Strengths and Limitations?*

OVERVIEW

Clinical-anthropometric methods are typically used to measure the more long-term, cumulative effects of dietary intake in relation to nutritional requirements by examining various indicators of physical health status. Anthropometry is a method of measuring the length, breadth, height, depth, thickness or circumference of segments of the human body (Jamison & Zegura, 1974). These measurements are used to make estimates of body size and body composition that indicate various states of growth and development. Clinical signs are used to detect the occurrence of disease conditions caused by the inadequate intake, absorption or utilization of nutrients.

Anthropometric measures provide indications of the overall sufficiency of energy and protein intake. They are less sensitive indicators of vitamin and mineral nutriture (Roa & Singh, 1970).

Deficiencies of specific vitamins can be detected by clinical signs and symptoms. Abnormalities of the skin, mouth, tongue and gums are seen in the "classical" deficiency diseases of beriberi (thiamin), pellagra (niacin), and scurvy (ascorbic acid). Specific changes in the skin and eyes are also observed in vitamin A deficiency. In addition, certain vitamin deficiency diseases, such as beriberi, are accompanied by abnormalities in the cardiovascular, respiratory, muscular, and neurological systems.

According to Sandstead (1979), the occurrence of vitamin deficiency diseases in the United States is usually associated with pathological social or medical conditions. Examples of social pathology include alcoholism, social isolation, food faddism, ignorance and neglect. Medical causes include intestinal malabsorption and iatrogenic factors (i.e., factors related to treatment of disease). These conditions seldom result in the deficiency of a single nutrient. Instead, they lead to mixed deficiency syndromes, with symptoms that are often non-specific and difficult to distinguish from symptoms of disorders that are unrelated to nutrition.

Because anthropometric measures reflect various states of growth and development, they are especially relevant in studies of the impacts of school nutrition programs on the nutritional status of school-age children. In the following sections of this chapter, anthropometric measures commonly used in surveys are described and their strengths and weaknesses are discussed. Protocols for obtaining anthropometric data and aspects of measurement reliability, cooperation of subjects, feasibility and costs are also described. Finally, the presentation and analysis of anthropometric data are discussed.

Clinical signs of vitamin deficiency diseases are extremely rare among school-age children in the United States. The evidence for this statement is presented in the review of literature on nutritional status of school-age children (Chapter III). In view of the low prevalence of these deficiencies, clinical measures of nutritional status do not appear to be useful indicators of potential impacts of school nutrition programs. Consequently, methods of assessing clinical signs of nutrient deficiencies are not reviewed.

DESCRIPTIONS OF ANTHROPOMETRIC MEASURES

Measurement of Body Size

The two measures most often used to estimate body size are height and weight. The length or width of body segments can also be measured. Common measures include knee height, sitting height, width of arms and legs, diameter of wrist, width of shoulders and hips. In addition, various indices of body size that relate height and weight can be constructed. These include simple weight for height comparisons and ratios such as the body mass index (W/H^2) and the "ponderal" index. The relative merits of each of these measures as indicators of growth and nutritional status are discussed below.

Height and Related Measurements. Height and measures of the diameter, length, and width of body parts are primarily indicators of skeletal size (Tanner, 1976). Height is a cumulative indicator of both biological and environmental influences (Waterlow, 1971) and is considered a stable measure of nutritional status, since it is relatively insensitive to short-term dietary deficiencies (Jelliffe & Jelliffe, 1971). Low height-for-age indicates "stunting" due to chronic malnutrition (Fomon, 1977).

Growth in height during childhood is indicated by the skeletal size the child has attained at any given age (i.e., distance) and the speed at which skeletal size increases over time (i.e., velocity).

A number of factors besides diet can influence the height of a child at any given age. Sex and genetic background are the most important non-nutritional influences. Much of the variation in height-for-age by sex and genetic background is due to differences in leg length. Males tend to have longer legs than females (NCHS, Ser. 11, No. 124, 1973). Blacks tend to have longer legs than whites, while Orientals and Mexican-Americans tend to have shorter legs than whites (Garn, 1979).

Chronic disease, recurrent infection, physical anomalies and a number of environmental factors such as socioeconomic status and sanitation can also affect the height attained at any given age. Some of these factors, such as recurrent infection, can have synergistic effects with malnutrition (Scrimshaw et al., 1968).

Under normal circumstances the speed at which children grow is relatively constant for both boys and girls during middle childhood, but a marked acceleration in the rate of growth is observed during adolescence. Data from the Health Examination Survey (NCHS, Ser. 11, No. 104, 1970) show that on the average, girls experience the adolescent growth spurt between 10-1/2 and 12-1/2 years of age and achieve their peak velocity in growth at 11-3/4 years. Boys usually experience the growth spurt later than girls, between 11-3/4 and 14-1/2 years, and hit their peak at 13-1/4 years. In girls, growth in height ceases around 17 years, but boys may continue growth beyond their 20th year (Heald, 1979).

Biological age is more important than chronological age in determining the onset, duration and intensity of the adolescent growth spurt for individual children. Biological age refers to the state of physiological maturity of the child. This can be determined by radiographic assessment of the skeleton (Garn, 1979) or by the onset of menarche in girls and the appearance of secondary sex characteristics (Tanner, 1962).

Some children experience a seasonal variation in their rate of growth. Prader et al. (1963) present an example where the child's normal springtime velocity in height growth was nearly double the autumn rate. The extent to which season affects growth is variable among children.

Even though children exhibit different heights-for-age as the result of genetic and environmental factors, and experience different rates of growth due to biological development and season of the year, the growth of any particular child will follow a fairly regular pattern. Waddington (1957) has referred to this phenomenon as "canalization" of growth. Illness or malnutrition can retard the growth process, but in periods of rehabilitation, the rate of growth will accelerate so that the child catches up with his or her normal growth channel. Prader et al. (1963) report that catch-up velocity in height can reach up to four times the normal velocity for age. The extent to which catch-up growth occurs depends upon the length of time growth has been retarded, the sex of the child, and whether puberty has been reached.

The catch-up phenomenon suggests that height would be an especially sensitive indicator of the effects of nutrition intervention for malnourished children. However, the individuality of growth rates and seasonal variations have implications for the design of studies that use height-for-age as measures of nutritional status and of impacts of school nutrition programs. Key considerations are whether the studies are cross-sectional or longitudinal and whether the data are analyzed for individuals or groups.

For children 6 to 10 or 11 years of age, cross-sectional data can allow for accurate placement of an individual at that point in time relative to the rest of the group (NCHS, Ser. 11, No. 104, 1970). However, evaluation of an individual child using cross-sectional data for height alone can be misleading during adolescence. Because every individual has a growth spurt that is unique in terms of its onset, duration and intensity, every child is more or less "out of phase" with other children according to chronological age (NCHS, Ser. 11, No. 124, 1973). Height-for-age measurements taken at a single point in time during adolescence cannot reveal the child's individual growth pattern. If the child appears taller or shorter than others in the cohort, it is impossible to know whether this is a reflection of nutritional status or simply the result of early or late entry into the growth spurt. Cross-sectional studies that seek to determine the growth status of individual children should collect supportive data on biological age. In cross-sectional studies that compare height-for-age among groups of children, differences in the timing, intensity, and duration of the adolescent growth spurt can be assumed to be normally distributed if the sample is representative; however, at a minimum, sex, race and socioeconomic status should be considered in the analysis, and children with chronic diseases or physical handicaps should be excluded from the study.

Longitudinal studies that attempt to assess impacts of nutrition intervention programs on changes in height of children over time must correct results for normal growth that would ordinarily occur between data-collection points. Because longitudinal studies are logistically more difficult than cross-sectional studies, sample sizes are usually not as large and may not be representative of the population. Sample means and variances therefore may be less accurate. Consequently, the estimation of normal growth between data points in a longitudinal study and the significance of changes from the normal pattern may not be meaningful unless growth patterns that existed in the sample prior to the intervention are known.

Seasonal variation in growth rates should also be taken into account in longitudinal studies, especially if the period of intervention coincides with the time of year where growth typically accelerates. This can be done by examining previous growth histories of individual children to detemine whether seasonal variations in growth rates have occurred.

Weight. Weight is a crude indication of body bulk or body mass and, in conjunction with height, reflects the overall status of physical development. The prevalence of individuals with low weight-for-age is typically used to describe the scope of undernutrition in a population (Bengoa, 1970), while the proportion with high weight-for-age has been used as an indicator of obesity. Yarbrough et al. (1974) have found that attained weight-for-age correlates well with severe protein-calorie malnutrition, but is a poor indicator of milder forms of the disease. They have also shown that body weight increments are not as sensitive as height increments to effects of nutritional intervention over short periods of observation when small samples of subjects (i.e., less than 100) are used.

In developed countries such as the United States, weight-for-age may more commonly be applied in assessments of obesity than in the detection of undernutrition. Obesity is defined as an excessive amount of body fat in relation to lean body (muscle) tissue. At the extreme end of the range for obesity, weight-for-age may be well correlated with body fatness; however, the association is not clear at intermediate levels. This is because weight is a gross measurement that does not separate skeletal and muscle components from body fat. Thus, a child with a low weight-for-age measurement may be normally proportioned but short, whereas a child with a high weight-for-age measurement may be heavy, but not obese, since the excess weight could be composed of muscle instead of fat.

Weight changes during childhood are not as regular as changes in height (NCHS, Ser. 11, No. 104, 1970). According to data from the Health Examination Survey, increments of mean weight from year to year for children between 6 and 11 are unequal, so that the curve of mean weight by sex and age is not linear as it is with height. The distributions are wider at older ages, so that children become more heterogeneous in weight than they do in height at ages 6 to 11 years.

The same is true in the adolescent years. There is a weight spurt in adolescence that generally parallels the spurt in height, but the curves connecting mean weight-for-age in the Health Examination Survey data are not as smooth as the curves for height. Also, the peak velocity in weight gain during the adolescent growth spurt is not as well defined. The best estimates from the HES data are that girls begin their weight spurts at 10-3/4 years and peak at 12-1/4 years. Boys begin their weight spurts at 12-1/4 years and peak at 13-3/4 years. The average durations of the height and weight spurts are almost identical for both sexes (NCHS, Ser. 11, 124, 1973).

A seasonal variation is also observed in the velocity of weight gain during the school years, but, in contrast to height, gains in weight tend to be greater in fall and winter than in spring and summer. Almost two thirds of the annual weight gain is accomplished between the beginning of September and the end of February (Malina, 1971). However, the time of year at which different children experience their seasonal weight gain peaks and the degree to which seaonal variations occur at all are highly individual (Tanner, 1962).

The same considerations in the design of studies using weight-for-age measurements apply as for height-for-age measurements. Cross-sectional studies must account for variations in the adolescent growth spurt when attempting to classify individuals. Longitudinal studies must account for seasonal variations and for the increments in weight that would normally occur between data-collection points.

Weight-Height Indices. Limitations of weight-for-age measurements have created the need for a more valid indicator of body bulk and obesity or leanness. The simplest index that can be constructed without taking additional body measurements expresses body weight in relation to height or as a function of height. The major advantage of such an index is that it removes the dependence of weight on skeletal size. Weight-for-height, the body mass-index (BMI), and variations of the "ponderal" index are commonly used.

Weight-for-height is a plot or cross-tabulation of weight at a given height. For group data, weights can be expressed as mean or median values for specified height intervals. Low weight-for-height is an indication of "wasting" due to acute undernutrition. High weight-for-height values in combination with normal height-for-age can be used as indicators of obesity.

Weight-for-height is a better indicator of obesity than weight-for-age because it relates body weight to skeletal size; it is still limited, however, since it does not allow one to distinguish between fat and muscle tissue (Garn, 1972).

Weight-for-height, or the simple ratio W/H, standardizes the relationship between height and weight into a simple linear dimension. However, body bulk or physique is a three-dimensional property similar to a volume measurement. A number of investigators have tried to capture this aspect of body composition by devising weight-height indices that are independent of height and highly correlated with weight or another independent measure of obesity.

Frerichs et al. (1979) used a method described by Benn (1971) to calculate the best weight-height index for predicting obesity in over 3,000 children 2 to 14 years of age who were examined in the Bogalusa Heart Study between 1973 and 1976. For children 2 to 5 years of age, the index which best fit the criteria of being independent of height and highly correlated with other measures of obesity was the Body Mass Index, W/H^2. However, in school-age children 5 to 14 years old, the best index was $W/H^{2.77}$, which is close in form to the "ponderal" index of relative weight invented by Rohrer--i.e., W/H^3.

Frerichs et al. recommend the use of the W/H^3 index as an indicator of adiposity and provide equations for converting the index to percentage of body fat in children 10 to 14 years old. They note, however, that none of the height-weight indices, including W/H^3, is as accurate as fatfold measurements for the estimation of the percentage of body fat in this age group.

DuRant and Linder (1981) compared five different weight-height indices with fatfold measurements taken on 103 children aged 7 to 15 in Augusta, Georgia. All children in this sample were black. The investigators also correlated the indices with height for 1,825 children aged 1 to 18, most of whom were black. The indices were W/H, W/H^2, W/H^3, H^3/W, and a weight-height index constructed by dividing W/H of the child by the W/H expected for age at the 50th percentile of the growth standards developed by the National Center for Health Statistics. It was found that the index providing the best indication of relative weight that was independent of height and age was not the same for all age-sex-race groups of children. The authors recommend that researchers who wish to use one of these indices as measures of relative weight in children should pretest the index's reliability on the particular data set in question. It cannot be judged a priori which index is least biased by height, age and race differences in children.

Measurements of Body Composition

As noted above, the chief limitation of all measurements of body size as indicators of obesity and leanness is that they cannot provide adequate estimates of the skeletal, muscular and fat components of the body. These elements of body composition are impossible to assess directly in living persons, although some cadaver studies of adults have been performed (Krzywicki, 1974). According to Frerichs et al. (1979), no cadaver studies have been performed on children. Consequently, all accounts of the validity of various methods for assessing body composition in children involve comparisons of indirect evidence.

Several laboratory techniques can be used to estimate the weight or percent of body components made of muscle, fat and other substances. These techniques involve estimating fat content by weighing the subject underwater or by administering fat-soluble indicators such as radioactive krypton gas (Womersley & Durnin, 1977). Muscle mass is usually estimated by counting emissions from the naturally occurring radioactive potassium in the body or by making calculations from estimates of total body water. The principles of these methods are described in a number of textbooks (e.g., Pike & Brown, 1975; Goodhart & Shils, 1980).

Since all of the laboratory techniques for estimating body composition require expensive equipment and highly skilled personnel, they are not practical in large-scale field studies. Instead, body composition is estimated by taking measurements at specific sites on the body and using this information to predict composition of the body as a whole (Haas et al., 1979).

Body fat is usually estimated by measuring the thickness of the fatfold beneath the skin. Circumferences measured at various sites are used in combination with fatfolds to estimate lean body mass or muscle area. Radiography can be used to measure bone thickness as well as muscle and fat. More recently, ultrasonic devices that are portable for field use have been designed to measure the thickness of fat and muscle tissue. Each of these methods is described and the validity of the measurements as indicators of nutritional status is discussed in the following sections.

Fatfold Measurements. Approximately 50 percent of the fat in normal human beings is found in a layer which "blankets" the individual directly beneath the skin. The remaining 50 percent of fat is located internally, usually surrounding organs such as the kidney (NCHS, Ser. 11, No. 120, 1972). At several sites on the body, it is possible to pinch a layer of skin and underlying adipose (i.e., fat) tissue away from muscle or bone and lift it up to form a skinfold (or, more accurately, "fatfold"). The thickness of this double layer of subcutaneous fat and skin is then measured with calipers. The principle of fatfold measurement is diagrammed in Figure II-2.

The layer pinched by the calipers includes a double thickness of skin as well as fat. In very lean individuals, the skin may constitute up to half of the thickness of the measurement (American Academy of Pediatrics, 1968). However, the thickness of the skin is not as variable as the thickness of the

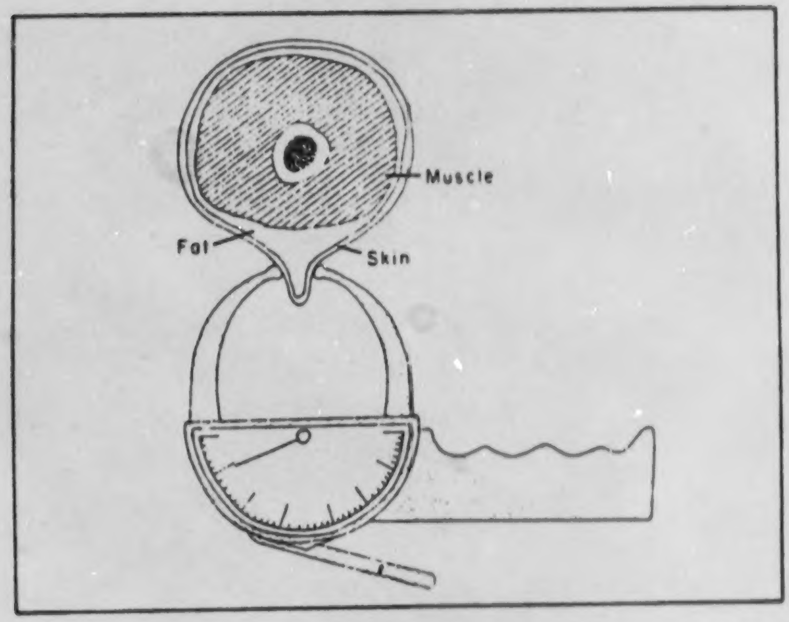

Figure II-2. Diagram of the Technique for Measuring a Skinfold, a Double Layer of Subcutaneous Fat and Skin

(In this case, the triceps skinfold is being measured with the Lange caliper. NCHS, 1972, p. 50.)

subcutaneous fat. Therefore, skin thickness is considered constant and fat is considered to account for all of the variability in the fatfold measurement.

It has been recognized for some time that the subcutaneous fat pinched by calipers is compressed up to 50 percent or more by the pressure of caliper jaws (Garn & Gorman, 1956; Brozek & Kinzey, 1960). Consequently, all caliper measurements systematically underestimate the actual thickness of subcutaneous body fat. The degree of compressibility varies by sex, age and fatfold site.

Himes et al. (1979) hypothesize that there may be many reasons for the variability in fatfold compression; among them are differences in skin tension and the distribution of fibrous tissue and blood vessels in the subcutaneous fat. Differences in hydration and nutritional status could also play a role. Although compressibility of fatfolds is of theoretical importance, insufficient data are currently available to adjust fatfold measurements in children for this factor. According to Himes et al., further research is needed to determine whether taking fatfold compression into account makes an appreciable difference in estimating total body fatness or in evaluating nutritional status.

The thickness of fat at various sites is not equal. Consequently, an important issue is the selection of fatfold sites that are the best predictors of total body fat. This can be determined by evaluating which site or combination of sites is best able to predict total body fat or the percentage of body weight as fat that is estimated from laboratory techniques.

Several investigators have reported correlations between body density or fat weight and fatfold thickness at various sites for normal-weight or obese school-age children. Pertinent features of these studies are shown in Table II-4. The correlation coefficients between fatfold sites and body density or

Table II-4. Results of Studies Comparing Fatfold Measurements with Laboratory Methods of Estimating Body Composition

Study	Sample	Laboratory Method	Fatfold Measures	"Best" Predictors*
Parizkova, 1961	Czechoslovakia 241 boys and girls aged 9-17 years	Body density	Cheek, chin, midaxillary, triceps, subscapula, chest, abdomen, illiac, thigh, calf	Sum of all 10 best predictors for all age-sex groups (.81) but triceps and subscapula give "adequate" estimates.
Heald et al., 1963	U.S.A. 66 boys aged 12-18 years	Body density	Triceps, biceps, scapula, pectoral, thorax, umbilicus, abdomen	Bracheal (i.e., triceps and biceps) better predictors of % body fat than fatfolds from chest region. $\underline{r}$ = .86 for triceps
Seltzer et al., 1965	U.S.A. 32 "obese" girls aged 12-18 years	Body density	Triceps, thigh, subscapula, pectoral, abdomen, knee	Triceps $\underline{r}$ = .69
Durnin and Rahaman, 1967	Britain 86 boys and girls aged 13-15 years	Body density (% body fat)	Biceps, triceps, subscapula, suprailliac	Total of all 4 in girls $\underline{r}$ = .78; biceps in boys $\underline{r}$ = .81
Michael and Katch, 1968	U.S.A. 48 boys aged 17 years	Body density	Triceps, chest, illiac, abdomen, subscapula, thigh	Illiac $\underline{r}$ = .86

*For convenience, signs indicating directions of relationships have been omitted from the table. In all comparisons with body density, $\underline{r}$ values are negative; $\underline{r}$ value in comparison with fat weight (kg) estimated by ^{40}K is positive.

Table II-4. Results of Studies Comparing Fatfold Measurements with Laboratory Methods of Estimating Body Composition (Cont'd)

Study	Sample	Laboratory Method	Fatfold Measures	"Best" Predictors*
Young et al., 1968	U.S.A. 102 girls aged 9-16 years	Body density	Chin, subscapula, chest (2 sites) side, waist, abdomen (2 sites), suprailliac, triceps, thigh, knee	Sum of all r = .73 higher 1 in premenarche (r = .81) vs. postmenarche (r = .71) girls. Best single site also varied by menarche status pre: midaxillary r = .80 post: abdomen r = .74
Forbes and Amirhakimi, 1970	U.S.A 472 boys and girls aged 7-18 years	40K (body fat kg)	Triceps, biceps, subscapula, subcostal, abdomen, umbilicus, illiac	Average of all 6 tended to be higher than single measures at all ages in both sexes. r range .49-.48 (boys) and .20-.87 (girls) depending on age. Subscapular generally higher than triceps in both sexes.
Harsha et al., 1978	U.S.A. 242 black and white boys and girls aged 6-16 years	Body density	Triceps, biceps, subscapula, suprailliac, subcostal, femoral, calf	Best single measure and combinations of fatfold and other anthropometric measures varied by sex and race: Best single measure for white males, white females, black males, was femoral fatfold (r = .80). Black females suprailliac fatfold r = .86.

*For convenience, signs indicating directions of relationships have been omitted from the table. In all comparisons with body density, r values are negative; r value in comparison with fat weight (kg) estimated by 40K is positive.

body fat estimated by laboratory techniques ranged from very low correlations of .20, to very high correlations of over .90, depending on sex, age and the particular sites that were assessed. In general, combinations of sites produced higher correlations than the use of a single site, but the differences were not very large. Correlations were also generally higher, regardless of sites measured, for boys than for girls (Forbes & Amirhakimi, 1970). Correlations for all sites were related more to biological than chronological age in one study of girls (Young et al., 1968). The difference by sex could indicate that girls carry more of their total body fat internally compared with boys, or carry more of it in subcutaneous areas that are not typically measured by calipers.

Examination of results from the various studies in Table II-4 does not reveal a single fatfold site that is the "best" predictor in all cases. In field studies, the triceps fatfold is often measured because it is more accessible than other sites (NCHS, Ser. 11, No. 120, 1972). Seltzer and Mayer (1967) have concluded that the triceps fatfold is more accurate than the subscapular fatfold for the classification of obese subjects.

The predictive validity of the triceps fatfold measurement can be improved when it is combined with height and weight. Frerichs et al. (1979) and Dugdale and Griffiths (1979) have used combinations of height, weight and fatfold measurements in statistical equations to predict fat weight or percent body fat estimated by laboratory techniques. The values predicted by the equations using height, weight and triceps fatfold corresponded well with the laboratory values in both studies. The amount of variation in body fat explained by the fatfold measures ranged from 75 to 92 percent. These predictions showed only moderate improvements when fatfold measures from additional sites were added to the equations.

Published equations such as those of Frerichs et al. and Dugdale and Griffiths can be used to convert height, weight, and fatfold measurements from other field surveys into estimates of fat body weight or percent body fat. However, some authors feel that predictive equations for body composition derived from one sample should not be used on another sample without validation (Smith and Boyce, 1977). If laboratory techniques are not feasible, characteristics of the two samples that might affect results should be compared.

Dugdale and Griffiths used data originally collected by other investigators of 77 boys and 86 girls aged 4 to 19 years in Great Britain. Ethnic and socioeconomic characteristics of these children may not be comparable to those of children in the United States.

Frerichs et al. derived their equations from 10-to 14-year-old children examined in the Bogalusa Heart Study. Although this sample contained a disproportionate number of low-income children and black children, the authors state that the Bogalusa children were similar on anthropometric measures to U.S. children sampled in the Health Examination Survey. Hence, their equations should be applicable to other representative groups of 10- to 14-year-old children.

Recently an argument in favor of converting fatfold thickness to an estimate of fat area has been promoted, on the basis that it takes more fat to cover a large area with a given thickness than it does to cover a small area with the same thickness of fat. This would suggest that fat area is preferable to simple fat thickness, since it is more highly correlated with total body fat. This assumption has been tested by Himes et al. (1980) on a sample of subjects containing 210 boys and girls 6 to 17 years old. Himes et al. found that overall, no appreciable advantage was gained by using fat areas instead of fatfold thickness to estimate percentage of body fat. However, when fatfold thickness and fat area measurements were correlated with fat weight (kg), higher values were consistently found for fat areas than the corresponding fatfold thickness. The authors conclude that if percent body fat is the variable of interest, fatfold thickness is just as good a predictor as fat area, but if attention is focused on absolute fat weight, conversion of fatfold thickness to fat area is preferred.

Mid-Upper-Arm Circumference. Muscle is the largest protein-containing organ in the body and the major component of lean body mass (Jelliffe & Jelliffe, 1969). The estimation of muscle mass is therefore an indirect indicator of protein reserves in the body. A number of accounts in the literature relate decreases in muscle mass to protein-calorie malnutrition. Standard et al. (1959) found that the decrease in muscle mass in children suffering from severe PCM was greater than deficits in body weight. The muscle calculations were significantly correlated with urinary excretion of creatinine, which is a biochemical index of muscle mass. When the children were given nutritional rehabilitation, the muscle measures increased.

Muscle strength has been shown to be proportional to arm muscle area. Malina (1979) suggests that children with mild-to-moderate undernutrition will have a reduced arm muscle area and a corresponding reduction in muscle strength.

Estimates of arm muscle area are calculated from measurements of the circumference of the upper arm and the triceps fatfold. The equations have been published by Frisancho (1974). Gurney and Jelliffe (1973) have developed normograms which simplify these calculations when high-speed computers are not available. Separate tables are given for children and adults.

Jelliffe and Jelliffe (1968) state that the mid-upper-arm circumference is relatively age-independent, at least in early childhood. Frisancho (1974), examining data from the Ten State Survey, did not find this to be the case for ages one to five and adolescence. However, compared with height and weight changes during these same years, the arm circumference shows a small change. Frisancho agrees that evaluations of arm circumference during childhood may not require an exact knowledge of age. However, Frisancho found that arm muscle area shows greater changes with age than arm muscle circumference. Assessments of muscle mass based only on arm circumference would underestimate the amount of change in muscle tissue occurring over time. Therefore, Frisancho recommends that evaluations of the nutritional status of children include the calculation of muscle area from the circumference measurement and that arm muscle area be expressed in relation to age.

All calculations of muscle size based on arm circumferences and fatfold measurements are subject to three limitations. First, it is assumed that bone diameters are the same for children of the same age and hence may be safely ignored in the arm muscle calculations. This assumption may not be valid. Male humeri, on average, are larger than the humeri of females so that regardless of nutritional status, male values of muscle size may be overestimated compared with females (Frisancho, 1974).

Second, the area calculations assume that the upper arm is cylindrical; however, it has been shown that the upper arms of males are flatter and more rectangular than those of females (Osborne & DeGeorge, 1959). According to Frisancho, this too could result in overestimates of arm muscle size in males compared with females.

Finally, none of the formulas compensate for fatfold compressibility. Since all fatfold measurements underestimate the thickness of subcutaneous fat, all estimates derived from equations using fatfolds will overestimate the thickness of muscle tissue. Clegg and Kent (1967) have found that triceps fatfold compressibility in young adult females is 4.8 percent greater than in males. If these differences in fatfold compressibility at the triceps also occur in children, this is another reason why muscle size in males may be overestimated compared with females. All of these limitations imply that arm muscle measurements should be analyzed separately by sex and that the values should be considered as relative indices of nutritional status rather than as absolute indicators of muscle (or protein) reserves.

Radiography and Ultrasound

Radiography and ultrasound are used for a variety of diagnostic purposes in research and clinical medicine. Their use in studies of nutritional status to assess body composition is only one of their many applications.

Radiography is a reliable and sensitive method of determining body composition at specific sites (Haas, 1979). As indicated above, it has been used to determine skeletal ages of children and to validate fatfold and muscle thickness measurements. The principle of radiography is that bone, muscle and fat absorb different amounts of X-rays. The X-ray plate taken of the upper arm, calf or thigh shows different shadows that represent the width of bone marrow, the whole bone, the muscle and fat tissue. Measurements of these various widths can be converted into cross-sectional areas (Haas, 1979).

Although portable equipment is available for use in the field, there are serious limitations to radiography in large-scale surveys involving children. Radiation exposure can produce sterility. Garn (1979) estimates the radiation dosage is approximately 2 to 5 millirads to the skin per radiograph, depending on the equipment and type of film. This exceeds the 1 to 2 millirads of daily background exposure in the environment. With proper procedures and use of a lead shield, the gonadal dosage should be below .1 millirads. This is considered a safe level, and for purposes of clinical diagnosis, the risk of radiation exposure is warranted. However, nutritional status surveys of essentially healthy school children offer no immediate benefits to the subjects. Unnecessary exposure of children to radiation in this situation is difficult to justify.

Ultrasound, like diagnostic X-rays, provides a "picture" of the layers of tissue underneath the skin. The advantage of ultrasound is that it does not expose the subject to radiation. The principles of ultrasound and its use in nutritional status assessment have been reviewed by Haas (1979). Ultrasonic energy is energy from high frequency mechanical vibrations above those audible to human ears. The energy can be focused into a narrow beam which is capable of penetrating dense matter, including living tissue. When the beam encounters the interface between tissues of different density some of the energy is deflected back as an "echo." The time required for the echo cycle is a function of the tissue thickness and density.

The ultrasound equipment used to determine body composition generates ultrasonic waves by an electrical-to-mechanical transducer. The transducer also converts the echo reflected back to electricity when the energy beam encounters different tissues. The electronic impulses are fed into an amplification and recording device. Two different systems, A-mode and B-scan, respectively, measure the depth of the tissue and produce cross-sectional estimates.

Ultrasonics was first used in body composition studies to measure the thickness of subcutaneous fat in livestock. In 1963, the technique began to be used experimentally for the assessment of body composition in humans. To date, only a small number of studies have compared ultrasonic measurements of fat and muscle tissue to measurements obtained with calipers, radiography or the various laboratory techniques. Generally high correlation coefficients in the range of .75 to .96 have been obtained (Haas, 1979; Sanchez & Jacobson, 1978; Booth et al., 1966).

The results of these studies are promising indications that ultrasound may ultimately prove to be the most valid and practical means of assessing body composition. However, its application to date has not included use in large-scale field surveys. Portable equipment is available (Body Composition

Meter, Ithaco Co.), but Haas (1979) has found that ultrasonic measurements using this device are subject to large interobserver error. When several observers must be used in a field study, the interobserver error with ultrasonics is potentially greater than the interobserver error using calipers. Furthermore, no studies of the validity of ultrasound for measuring fat and muscle have been conducted on healthy school-age children, and there are no generally recognized standards for interpreting ultrasonic measurements in this age group.

Discussion

Body size and body composition are indicators of growth and development in children. Anthropometric measurements of body size and body composition are sensitive to the effects of energy and protein nutriture on growth and development, but are less sensitive to the effects of vitamin and mineral status (Roa & Singh, 1970).

Height and weight are the two measures commonly used to estimate body size. Height primarily reflects skeletal growth (Tanner, 1976). Low height-for-age is usually considered an indication of "stunting" due to chronic undernutrition (Fomon, 1977).

Weight is a gross indicator of body mass. Low weight-for-age can be used as an indication of "wasting" due to acute undernutrition. High weight-for-age can be used as an indication of obesity (i.e., excess body fat) due to overconsumption of calories. However, total body weight is a limited measure of these states because it does not separate fat tissue, muscle, and skeletal components. Both height and weight can be influenced by genetic and environmental factors that are unrelated to nutrition.

Growth in height is essentially linear in early and middle childhood, but exhibits an abrupt "spurt" in girls and boys at about 10 and 11-1/2 years, respectively. Weight follows a similar but more erratic pattern (NCHS, 1970). Seasonal variations in growth have also been observed. Some children gain more rapidly in height during the spring and summer than in fall and winter (Prader et al., 1963). Weight has an opposite pattern of seasonal variation. Some children experience as much as two-thirds of their annual weight gain during the fall and winter months (Malina, 1971).

Growth among children is highly variable--expecially with respect to the timing, intensity and duration of the spurt in adolesence. However, an individual child will follow his or her own "channel." Following periods of malnutrition, growth accelerates so that children catch up with their original growth curves. The extent of catch-up growth depends upon the severity and extent of the nutritional deprivation.

All of these factors have implications regarding the use of height and weight data to measure the impacts of school nutrition programs. Cross-sectional data can be validly used to assess the growth status of individuals and groups of children provided that sufficient controls are used to account for non-nutritional factors. Variability in the timing, intensity and duration of the adolescent growth spurt makes it desirable to obtain data on biological as well as chronological age for children who are ten years old or more. This recommendation is especially important in longitudinal studies attempting to measure changes in growth that result from nutritional interventions. In addition, longitudinal studies must account for normal growth and seasonal variations that occur between data-collection points.

In addition to height-for-age and weight-for-age, various indices can be used to estimate relative weight. Weight-for-height, which is simply a cross-tabulation of the two measurements, is preferred over weight-for-age as a measure of obesity because it controls for skeletal size (Waterlow, 1972; Fomon, 1977; Weil, 1977). Weight-for-height is relatively age-independent in prepubescent children, but it cannot be used with confidence in older children without evidence of biological age.

The body mass index (W/H^2) and the various "ponderal" indices are also indicators of relative weight and obesity. Frerichs et al. (1979) have shown that W/H^3 has a high correlation with measures of obesity in children 5 to 14 years of age. However, the reliability of each index should be evaluated for a given sample (DuRant & Linder, 1981). None of the measures based solely on height and weight can predict body fatness as well as fatfold measurements.

Body composition is generally assessed in surveys from fatfold and arm circumference measurements. Fatfold measurements estimate the thickness of subcutaneous fat at specific sites using special calipers. No single site is a completely accurate predictor of total body fat as determined by laboratory methods. The triceps measure has been shown to correlate highly with laboratory values in a number of studies. The triceps is also more accessible than other fatfold sites (NCHS, Ser. 11, No. 120, 1972) and is better able to classify obese subjects (Seltzer & Mayer, 1967).

All fatfold measurements are limited by the compressibility of fat tissue by the jaws of the calipers. Consequently, fatfold measurements underestimate the amount of fat present. Variation in fatfold compressibility has been discovered among children of the same age and sex (Himes, 1980).

Arm muscle area is calculated from measurements of the triceps fatfold and the mid-upper-arm circumference. It corresponds to protein reserves in the body (Jelliffe & Jelliffe, 1969) and muscle strength (Malina, 1979). Arm muscle area is reduced in children suffering from protein-calorie malnutrition.

Because the arm muscle circumference is derived from the triceps fatfold measurement, it is subject to the same vulnerabilities. To the extent that subcutaneous fat is underestimated, the corresponding muscle area is overestimated. In addition, differences in the size of the humerus and shape of the arm among individuals are not taken into account (Frisancho, 1974).

Radiography and ultrasound are more accurate methods than fatfold and circumference measures for estimating the thickness of subcutaneous fat and arm muscle area; however, both have limitations for use in field surveys. Radiography exposes children unnecessarily to radiation, while ultrasonic devices are subject to interobserver measurement error (Haas, 1979).

PROTOCOLS FOR ANTHROPOMETRIC MEASUREMENTS

Compared with dietary and biochemical techniques, anthropometric measurements are relatively simple and straightforward. However, one of anthropometry's major weaknesses is related to errors introduced by poor measurement techniques (Zerfas, 1979). Krogman (1971) reports that in compiling a review of 600 studies on child growth, nearly 300 studies had to be dismissed because of inadequate sample sizes, poor statistical analysis, or "sloppy" measurement. Garn (1979) estimates that about 3 percent of all measures may be in error, primarily due to mistakes in identification, measurement, transcription, coding, and card reading. A survey conducted by the Center for Disease Control (1975) found frequent measurement errors in state and local health clinics due to poor instruments and poor reading and recording techniques. These errors affect the reliability of anthropometric data. Studies which employ multiple teams of data collectors are especially subject to these sorts of problems. In such studies, the techniques used to take the measurements must be standardized and carefully controlled.

In this section protocols and quality control procedures for taking height, weight, fatfolds and mid-upper-arm circumference measurements are described.

Because radiography and ultrasound are not suited to large-scale studies of school children, protocols for these techniques are not discussed.

The discussion of protocols centers on methods, instruments, personnel, training and quality control. Reviews of these topics have been provided by Falkner (1961), Jelliffe (1966), the American Academy of Pediatrics (1968), Tanner et al. (1969), Owen (1973), Cameron (1978) and Zerfas (1979).

Much detailed information on the development and use of anthropometric protocols has been derived from large-scale studies of the U.S. population conducted by the National Center for Health Statistics. This agency of the Department of Health and Human Services (formerly Department of Health, Education and Welfare) has conducted periodic surveys of the health status of various segments of the U.S. population since 1959. Cycle II of the Health Examination Survey (HES) was conducted from 1963 to 1965 on a probability sample of non-institutionalized children aged 6 to 11 years. The program succeeded in obtaining a response rate of 96 percent of the 7,417 children selected for the sample. The examination consisted of two parts: (1) an assessment of factors related to growth and development conducted by a physician, nurse, dentist, and psychologist; (2) a variety of somatic and physiological measurements performed by specially trained technicians.

Between 1966 and 1970, Cycle III of the HES obtained data on 12- to 17-year-old children comparable to data obtained in Cycle II. The same primary sampling units were used for Cycle III, so that approximately 30 percent of the children were the same individuals who had been examined in Cycle II. The response rate for Cycle III was 90 percent of the total sample of 7,514 children.

The National Center for Health Statistics initiated another survey, the Health and Nutrition Examination Survey (HANES), which added a special emphasis on nutritional status to the basic HES design. This survey was conducted from 1971 to 1975 on a sample of subjects 1 to 74 years old. Details of the sample are provided in the chapter on school nutrition program impacts (Chapter IV). HANES completed a second cycle of data collection from 1975 to 1979.

Height

Instruments. The instruments for measuring height range from simple graduated measuring tapes fastened against the wall to more precise anthropometers (scaled measuring rods) and custom-made boards with moveable crossbeams or more expensive commercial stadiometers (boards with a scale attached) with digital printouts (Zerfas, 1979). The freestanding heightboard is most commonly used in surveys. The equipment used in HES consisted of a level platform with an attached vertical bar. The vertical bar measures height on a steel tape. Perpendicular to the vertical bar is another horizontal bar which slides down to fit snugly over the subject's head. A Polaroid camera is attached to a second moveable horizontal bar positioned in the same plane as the first. The camera records the subject's ID number next to the pointer on the measuring tape. This not only provides a permanent record of the reading, thus reducing errors in coding and transcription, but it also eliminates measurement error due to parallax, i.e., the tendency for an observer to read too high a measurement when looking up at the scale or too low a measurement when looking down on the scale. A number of investigators (e.g., Fomon, 1977; Zerfas, 1979) advise against using the height attachments on weighing scales. The headpieces are wobbly and too narrow to obtain accurate measurements.

Position of Subject. Positioning the child is an important aspect of height measurements. School-age children are usually measured for standing height (stature) rather than recumbent length. It has been recognized for some time that all subjects measure shorter when standing compared with lying down. This is because gravity compresses the spaces between the vertebra of the spine when subjects are standing up. Roche and Davila (1974) have calculated that over the entire age-span of 6 to 18 years, median differences between stature and length range from approximately 1.1 (age eight) to 2.9 (age 14) centimeters. The loss in stature occurs when subjects stand for at least one hour. This loss is regained when subjects lie down for the same period of time.

The loss in height on standing has led some investigators to recommend that examiners exert an upward pressure on the subject's mastoids to "stretch everyone in a standard manner" (NCHS, Ser. 11, No. 120, 1972). The upward pressure technique can increase the subject's standing height by as much as 1 cm. This technique was not used in HES, but children were asked to "stand up real straight" and "look straight ahead." Falkner (1961) suggests that the child's heels, buttocks and shoulders should be against the wallboard. Shoes should be removed. Heels should be together and the feet should make a 45° angle with each other in a comfortable stance. The examiner should see that the axis of the child's vision is horizontal and that the auditory meatus (opening to the ear), the acromium process of the shoulder, the hip trochanter and the anklebone are all in one perpendicular line. The child should stay in place until the measurement is read, so that the headboard does not slip. Readings should be recorded to .1 cm or less (Zerfas, 1979).

Other Factors. The time of day can affect the height measurement. As early as the 18th century, it was observed that children decrease in height over the course of the day. Baker et al. (1978) report data from over 3,500 children 7 to 9 years old showing mean height differences of approximately 1/2 cm in the morning versus the afternoon. Protocols for cross-sectional studies should assure that measurements that are intended to be compared for different groups of children are equally distributed throughout the day. In longitudinal studies, the time of day when the initial measurement is taken should be recorded for each child so that subsequent measurements can be taken at a comparable time.

Weight

Instruments. In a survey of practitioners from pediatric nutrition clinics throughout the world, Jelliffe (1968) found that the preferred scale for recording weights in field studies should (1) be inexpensive, (2) have an accuracy to .1 kg, (3) be sturdy, durable and easy to clean and repair, (4) be easily transportable, (5) have clear readability, (6) have a sufficient weight range, (7) have a nonfrightening appearance, and (8) have an appropriate weighing surface. While several devices meet these characteristics for infants and young children, there remains a need for inexpensive, sturdy, portable scales for older children and adults (Zerfas, 1979).

The Detecto balance beam scale is used in many health centers in the United States. It weighs subjects up to 140 kg (250 lbs) in .1 kg intervals. Duplicate measurements obtained in the Bogalusa Heart Study on a Detecto scale and an automated electronic scale (National Controls, Inc.) agreed within .5 kg for 99.9 percent of the observations (Berenson, 1980). A disadvantage of the Detecto scale is that it is bulky to transport and requires frequent calibration in the field (Zerfas, 1979).

HES used a Toledo self-balancing weight scale that mechanically prints out weights directly onto a permanent record (NCHS, Ser. 11, No. 104, 1970). Recorded weights were later transferred to a punched card to the nearest half pound. The scales were calibrated about once a month--each time the scale was moved to a new site.

Zerfas (1979) states that spring bathroom-type scales should not be used in surveys unless portability and availability override all other considerations. These scales do not provide the precision required for scientific purposes and must be frequently calibrated.

Clothing. A major issue in the development of protocols for measuring weight is how to account for the weight of subjects' clothing. Falkner (1961) insists on nude weight, but this requirement is often impossible to carry out in the field. The next best alternative is to provide subjects with lightweight shirts, shorts and gowns to wear during the examination. This procedure was followed in HES. However, the weight of the clothing (ranging from .24 to .66 lb.) was not deducted from the body weight measurements. Consequently, all weights reported from HES are .24 to .66 above nude weight, recorded to the nearest half pound.

If separate weighing rooms are not available for boys and girls or the weighing cannot be scheduled separately for each sex, having subjects change into special garments for the examination may not be feasible. In this case, all obvious sources of excess weight (e.g., shoes, heavy jewelry, belts, etc.) should be removed. If notification of the examination can be given in advance, children should be asked to wear lightweight garments. In wintertime, outer garments (jackets, coats, sweaters, hats, etc.) should be removed. Several sets of "typical" clothing can be weighed in order to estimate the range of measurement error. The average weight of the clothing can also be subtracted from the individual weight measurements (World Health Organization, 1970). The latter procedure was followed in the Ten State Survey (Center for Disease Control, 1972).

Other Factors. There are other factors besides clothing that can produce short-term variations in the weight measurements of an individual. For example, changes in body weight can be due to changes in hydration and the contents of the gastrointestinal tract. Yarbrough et al. (1974) estimate that these factors can cause weight to vary as much as 200 grams when repeated measurements are taken on the same child from day to day. This variation is far greater than the variation caused by errors due to the precision of scales and observers' measurements. Of all anthropometric measures, weight is unique in this regard (Zerfas, 1979). To the extent possible, anthropometric protocols should control for intraindividual variation. Children should visit the bathroom before weight measurements are taken. In longitudinal studies, weight should be recorded at the same time of day as the previous measurement.

Fatfold Measurements

Instruments. Calipers for measuring fatfolds should be spring-loaded to the closed position and compress the fold with a constant pressure of 10 grams/ mm^2 throughout the range of openings (NCHS, series 11, No. 120, 1972). A number of instruments meet these specifications, but the Lange and Harpenden models are used most often. The Lange caliper (pictured in Figure II-2) is manufactured in the United States and is less expensive than the Harpenden. Keys (1971) states that the two types of calipers give equivalent results, but does not give details of the comparisons. Zerfas (1979) says that plastic calipers are not recommended, especially for children, because they have inadequate springs and incorrect tensions.

The "anthrogauge" is another device for measuring fatfolds. It is a flat plastic sheet 1/8-inch thick with notches of selected widths. The fatfold thickness is measured by inserting it into the most appropriate notch. Separate gauges are made for the different age groups. Although the anthrogauge is inexpensive and convenient, it gives only an approximate measure of fatfold thickness and is still in the testing phase (Zerfas, 1979).

Measurement Techniques. Finding the exact location of the fatfold site on each subject can be a problem, especially if the subject is obese. Protocols should include exact instructions to examiners. Subjects may be asked to disrobe so that the fatfold and body landmarks are more accessible.

The fatfold should be lifted by a firm grasp with the thumb and index finger about 1 cm above the site where the calipers are to be placed. The examiner must be careful not to pinch the underlying muscle, as this is painful to the subject. The width of the fatfold that is lifted varies with the site and the thickness of the subcutaneous fat. It is therefore difficult to standardize this aspect of the procedure. For any given site, the width of the pinch should be minimal yet still yield a well-defined fold (NCHS, Ser. 11, No. 120, 1972).

While the pinch is being held with one hand, the examiner uses the other hand to place the jaws of the calipers around the fatfold. This should be done so that contact surfaces of the calipers are parallel and are at the same depth as the pinch. Because the fatfold is compressible, the reading on the gauge will decrease slightly after the caliper is applied. Investigators recommend waiting two to three seconds after the caliper is applied before taking the reading (Zerfas, 1979; Fomon, 1977). Taking a second reading without releasing the pinch is also recommended (Zerfas, 1979). In HES, examiners were instructed to continue taking measurements at the same site until measurements agreed to within 1 mm. Zerfas (1979) recommends taking an average if consistent readings on children are not obtained after three measurements.

Mid-Upper-Arm Circumference

Instruments. Steel measuring tapes have been popular for measuring arm circumference in field surveys. The steel tape used in HES was a flexible tape with a spring rewind scaled in centimeters and millimeters on one side and inches on the other. A fiberglass tape was used in HANES (NCHS, Examination Staff Procedure Manual, 1975-1979).

Recently Zerfas (1975) has introduced a tape that inserts into itself so that the measurement is read through a "window." Two arrows guide the insertion, one next to the window slot and the other at the distal end of the tape. The measurer threads the tape through the slot from behind and the free part of the tape is drawn through the slot to the required tension around the arm. The reading is made at the point of the two arrows, perpendicular to the long axis of the tape. Compared with conventional tapes, the insertion tape improves control, alignment and reading of the mid-upper-arm circumference. Test-retest mean differences are about 4 mm. In a study involving five measurers and nine young children, it was found that the mean of the standard deviation in head circumference measurements using the insertion tape was significantly lower than the mean of the standard deviation using a steel tape.

Measurement Techniques. The site for the mid-upper-arm circumference measurement is located in the same way as for measurement of the triceps fatfold. In U.S. surveys, both the triceps fatfold and the mid-upper-arm circumference are usually measured on the right side. If both measurements are being performed, the circumference is generally measured first. The circumference is measured while the subject's arm hangs loosely at the side. The examiner must make sure the tape is horizontal and is in contact with the skin but not wrapped so tightly that it deforms the skin contours. Readings are taken to the nearest .1 mm.

Personnel, Training and Quality Control

No recommendations concerning the level of personnel that must be used to obtain anthropometric measurements are found in the literature. All personnel performing measurements in HES were experienced X-ray technicians who had been trained in anatomy and the identification of body landmarks. Additional qualities of the technicians were that they worked well with people and were skilled at giving people verbal orders and the handling necessary to position the subjects correctly (NCHS, Ser. 11, No. 120, 1972).

An eye for accuracy and a friendly manner with children might also be added to the list of desirable traits.

In studies taking only basic measurements (i.e., height, weight, triceps or subscapular fatfold and mid-upper-arm circumference), it is possible to use inexperienced personnel if adequate training is provided and quality control measures are instituted. Most studies use teams, each consisting of two examiners. One person takes the measurements while the other records the measures and performs quality control. Zerfas (1979) suggests that the training schedule for examiners include:

- Procedure and instruments demonstration
- Instrument practice under supervision
- Trial practice review
- Standardization test (i.e., compare results of measurements on same child taken by supervisor and trainee)
- Review and practice under simulated field conditions
- Further standardization test if required
- Field trials under supervision
- Review

The program of training and quality control for HES had two broad goals: (1) to reduce the variability from measurement efforts, and (2) to assess the magnitude of the remaining residual error (NCHS, Ser. 11, No. 120, 1972). The procedures were as follows:

- Initial training of examiners.
- Periodic direct observation by supervisors as the measurements were being taken with correction of errors when necessary.

- Practice and retraining during "dry runs" in the field performed on the first day at each new location. During this time all equipment was retested and recalibrated.
- Formal standardization tests conducted every six to nine months by the supervisors. Each session lasted two days. Two boys (one quite fat, the other lean) were involved in measurements each time. On the first day the boys were measured by each of the examiners with supervisors acting as recorders. The following day, the procedure was repeated, thus giving both interobserver and intraobserver measurements for quality control comparisons. Major discrepancies were noted and attempts were made to identify and eliminate their causes.
- Daily instrument checks were performed. For example, calipers were checked by inserting wedges of known width. Adjustments in the calipers were made when the readings did not correspond. Several additional calipers were available in case a set in use could not be calibrated accurately.
- Field analysis of replicate measures. In the field phase of Cycle III, 5 percent of the examinees returned for remeasuring, usually after two to three weeks. At the time of the original examination, neither the examiner nor the subject knew if the subject would return for a replicate examination. Reexaminations were interspersed with initial examinations during the measurement sessions.

Discussion

Anthropometric protocols include the specifications for equipment, personnel and procedures for taking height, weight, fatfold and circumference measurements. Standardization of protocols is designed to reduce measurement error.

Several different types of equipment are available for each anthropometric measure. Selection usually involves a trade-off between precision and cost. Personnel need not be experienced for studies taking a limited number of measurements as long as training and quality control programs are instituted.

Positioning the child is important in height measurements. Some investigators recommend "stretching" the child by exerting upward pressure on the mastoids, but this has not generally been done in large U.S. surveys.

Both height and weight are subject to diurnal variations. The weight measurement is also particularly subject to intraindividual variations from day to day due to clothing worn by the child, hydration and contents of the bladder and GI tract. These factors must be considered in the development of anthropometric protocols, especially those that will be used in longitudinal studies where repeated measurements of the child are expected to reveal small but significant changes.

The technique for taking fatfold measurements requires personnel to be sufficiently trained to locate sites accurately, lift the fatfold from the underlying muscle and bone, and read the value on the caliper gauge. Circumference measurements require the same degree of precision in locating sites, positioning the measuring tape and reading the circumference values. The procedures for taking these and other anthropometric measurements in large-scale field studies have been well developed and standardized in HES and HANES.

RELIABILITY OF ANTHROPOMETRIC MEASURES

The procedures for standardization of protocols, training and quality control are all aimed at improving the reliability of anthropometric measures. Measurement error is the primary source of unreliability but, as noted above, intraindividual variation due to season of year, time of day, bladder contents, etc., can affect measurements of height and weight.

Zerfas (1979) has provided a list of common causes of measurement error for various techniques. Common sources of error for all measurements are (1) inadequate instruments, (2) restless child, (3) reading part of instrument not fixed when value is taken, (4) reading in error, and (5) recording in error. Other problems that can plague specific measurements are shown in Table II-5.

Several studies conducted from 1926 to 1941 indicated that the extent to which measurement errors of the kind listed in Table II-5 occur in surveys is influenced by several factors (Gavan, 1950). In general, reliability of the measurements increases when the number of examiners decreases, the amount of subcutaneous tissue decreases, the experience of the examiner increases, and the landmarks used to locate sites are more clearly defined. These types of errors can be attributed to measurement techniques used by the same examiner on different subjects (intraobserver error) and by different examiners on the same subjects (interobserver error).

A number of more recent studies have attempted to quantify the amount of intraobserver or interobserver error that occurs with various anthropometric measurements (Gavan, 1950; Kemper & Pieters, 1974; Jamison & Zegura, 1974; Martorell, et al., 1975; Rauh & Schumsky, 1968).

The most comprehensive assessment for children was performed in HES with the replicate data from Cycle III described above. In Cycle III, 11 technicians made replicate examinations on a total of 301 children--224 children were reexamined by different technicians, 77 children were reexamined by the same technician. Differences in measurements obtained by the same (intraobserver) and different (interobserver) technicians were assessed for height; weight;

Table II-5. Common Errors of Measurement in Anthropometry (Zerfas, 1979)

Height	Incorrect age for instrument
	Footwear or headgear not removed
	Feet not straight nor flat on floor
	Knees bent
	Body arched or buttocks forward
	Head not in correct plane
	Shoulders not straight on board
	Headboard not firmly on crown of child's head
Weight	Room cold, no privacy
	Scale not calibrated to zero
	Child wearing unreasonable amount of clothing
	Child moving or anxious
Triceps fatfold	Wrong arm
	Mid-arm point or posterior lane incorrectly located or marked
	Arm not loose by side during measurement
	Examiner not comfortable or level with child
	Finger-thumb pinch or caliper placement too deep (muscle) or too superficial (skin)
	Caliper jaws not at marked site
	Reading done too early, pinch not maintained, caliper handle not fully released
Arm circumference	Tape too thick, stretched or creased
	Wrong arm
	Mid-arm point incorrectly located or marked
	Arm not loose by side during measurement
	Examiner not comfortable or level with child
	Tape not around mid-point, too tight, too loose

triceps, subscapular, and midaxillary fatfolds; and mid-upper-arm circumference.

The arm circumference measurements showed no significant differences between replicates, but the replicate height data obtained by different technicians varied by approximately .5 cm between examinations and the weight data varied by about 1 kg. This difference was not significant for weight, but for height the difference was significant at the .05 level of probability. The finding is reasonable in light of the protocols used in HES for these two measures. Weight measurements were completely automated; the only involvement of the technician was to ask the child to get on the scale. Height measurements were also recorded mechanically with the Polaroid Camera, but the technician had to position the child properly. The authors note that much of the interobserver variance in the height measurement was attributed to a difference of 10.3 cm for one child. This large a difference occurred despite the rigorous efforts to standardize procedures through training and quality control.

The HES data for replicate fatfold measures give the impression that the triceps site is subject to greater error than the subscapular and midaxillary sites. Part of the reason is that the thickness of the triceps fatfold is greater than the subscapular and midaxillary fatfolds. Average values across all ages and sexes in Cycle III of HES were 12.25 mm, 9.97 mm, and 9.47 mm for the triceps, subscapular and midaxillary fatfolds respectively. When the HES data are corrected for this difference in fatfold thickness, the triceps no longer is the least reliable of the three measures. The interobserver error for the triceps is comparable to that of the subscapular fatfold and the intraobserver error is significantly lower. The midaxillary fatfold has the worst reliability of the three measurements.

Several investigators have found that reliability of fatfold measures decreases when subjects are obese. Rauh and Schumsky (1968) found this to be the case in a reliability study of triceps fatfold measurements taken on 1,130 children aged 6 to 17 in Cincinnati, Ohio. In this study three technicians measured fatfolds with Harpenden calipers. A small but consistent difference between examiners was observed that was attributed to measurements taken on girls whose weights were over 72 kg or whose triceps fatfolds measured more than 30 mm. In these subjects the fatfold was difficult to pick up and the caliper often did not fit the contour of the skin.

The findings on reliability of the triceps fatfold measurements imply that a single examiner is always preferable in a longitudinal study, since a single observer will obtain more consistent readings for changes over time even though the absolute values may not be accurate for the population (NCHS, Ser. 11, No. 120, 1972).

The number of examiners to use in cross-sectional studies measuring the triceps fatfold depends on whether the intention is to describe the distribution of values in the population or compare values between groups. If the purpose is to estimate the population distribution, multiple examiners will provide better results, since systematic error will be reduced. If the purpose is to compare groups, the study is faced with an irreconcilable dilemma: multiple examiners will increase the variability of the data (thus decreasing the likelihood of detecting significant differences), while a single observer may measure different kinds of individuals (e.g., obese vs. lean) in a systematically different way (NCHS, Ser. 11, No. 120, 1972). When use of multiple observers is the only feasible alternative, training and standardization procedures become extremely important in reducing the potential for interobserver error.

Discussion

It has been shown that one of the greatest weaknesses of anthropometric measurements is their unreliability. Even with the precise highly automated equipment used in HES, interobserver errors still occurred for height and weight. Errors in fatfold measurements are greater than errors in other anthropometric measures, especially when subjects are obese. HES data indicate that a single examiner is always preferable to multiple examiners in longitudinal studies. The number of examiners to use in cross-sectional studies depends upon the fatfold site being measured. The triceps fatfold presents an insoluble dilemma, in that a single examiner may introduce systematic bias while errors resulting from multiple examiners jeopardize the possibility of finding significant differences among groups of subjects. Further research is needed to estimate errors in triceps fatfold measurement and other indicators, such as arm muscle area, that are derived from triceps fatfold values.

COOPERATION OF SUBJECTS, FEASIBILITY AND COST

The literature provides very little information about the cooperation of subjects and the feasibility and cost aspects of anthropometric measures. No formal studies have been conducted, but various investigators have made comments based on their field experiences (e.g., Habicht et al., 1979; Garn, 1979; Zerfas, 1979).

Relative to dietary and biochemical measurements, cooperation of subjects in anthropometric measurements is generally high. The measurements can all be taken at one time and require little from the subjects beyond their submission to the examination. However, it can be expected that some children might refuse a physical examination to determine biological age, since the questions and procedures may be embarassing. When proper techniques are used, none of the anthropometric measures are painful for the subjects, but the appearance of some instruments, especially fatfold calipers, can be frightening to young children. In the Bogalusa Heart Study, procedures and equipment were explained to the children before taking the measurements in order to reduce their apprehension (Berenson, 1980).

Aside from travel costs, the major costs of conducting anthropometric measurements in the field are due to equipment and personnel. A comparison of the costs of various anthropometric equipment is shown in Table II-6. The selection of equipment involves a trade-off between cost and precision. Generally, those instruments that are the most precise are also the most expensive. The convenience in packing and transporting the equipment, its durability, and requirements for maintenance and calibration are also factors to consider.

Personnel costs are determined by the level of expertise required, the training program, and the amount of time spent in the field. Skilled anthropometrists may be required in studies taking large numbers of measurements requiring precise location of sites; however, studies taking only a basic set (e.g., height, weight, arm circumference and triceps fatfold) can usually get by with less expensive personnel, provided that training is adequate. A typical training period for inexperienced examiners is one to two weeks (Zerfas, personal communication).

The time spent in the field is a function of the sample site, the number of measurements taken per subject and the amount of travel between sites. Extra time is also added by the procedures for recording and coding data and for quality control. Zerfas (1979) estimated that 14 to 19 hours of staff time (total) was needed on-site to take anthropometric measurements and other tests (not described) on 30 preschool children and their mothers in a recent nutritional survey in Africa.

Table II-6. Comparative Costs of Anthropometric Equipment (Adapted from Zerfas, 1979)

Relative Cost	Measurement			
	Weight	Height	Circumference	Fatfold
High	Toledo with automatic digital readout Other heavy-duty scales, e.g., Office Detecto	Stadiometer, Custom-made board with Polaroid camera		Precision calipers, e.g., Harpenden, Lange
Medium	Salter scale Portable Detecto	Custom-made boards	Metal tape	Plastic anthrogauge
Low	Bathroom scale	Graduated stick	Fiberglass tape; insertion tape	Cardboard anthrogauge

Discussion

Most anthropometric measures are feasible in large-scale surveys and, relative to dietary and biochemical methods, pose few problems of cooperation from subjects. The costs of anthropometric equipment vary with the precision of the instruments. Personnel can be inexperienced as long as adequate training and quality control programs are built into the survey. Field costs depend on the sample size and the number of measurements. A basic set of height, weight, arm circumference and triceps fatfold data can be obtained in 15 to 20 minutes per subject.

ANALYSIS OF ANTHROPOMETRIC DATA

Analysis of anthropometric data can have three objectives: (1) presentation of the values obtained in the sample, (2) comparison of the sample with a reference population, and (3) classification of individuals according to nutritional status and/or description of the prevalence of nutritional problems in the population. Classification of nutritional status and description of the prevalence of nutritional problems involve comparisons of anthropometric values for the sample with appropriate standards defining undernutrition (stunting, wasting) and obesity.

When sample data are compared to distributions in another population, a distinction must be made between a reference and a standard (Waterlow et al., 1977). A reference population can be chosen without regard to its socioeconomic and genetic characteristics. The major considerations have to do with quality of the data collection and analysis procedures and presentation. Waterlow et al. list the following criteria for selecting a reference population:

- Measurements should relate to a well-nourished population.
- The sample should include at least 200 individuals in each age-sex group.

- The sample should be cross-sectional, since the comparisons that will be made are of a cross-sectional nature.
- Sampling procedures should be defined and reproducible.
- Measurements should be carefully made and recorded by observers trained in anthropometric techniques using equipment of well-tested design and calibrated at frequent intervals.
- The measurements made on the sample should include all anthropometric variables that will be used in the evaluation of nutritional status.
- The data from which reference graphs and tables are prepared should be available and procedures used for smoothing curves and preparing tables should be adequately described and documented.

In contrast, anthropometric data used as standards for the assessment of growth and nutritional status must consider how socioeconomic factors affect growth patterns, and whether all child populations, regardless of racial background, have the same genetic potential for size and body composition. The International Union of Nutritional Sciences, meeting in 1971, stated that "the definition of 'optimum' is clearly complex and difficult.... Each country's own standards must be derived from carefully selected samples representing children growing in an optimal environment for that country. Genetic and racial factors must be defined and appropriately represented in the sample." The IUNS recommended that the samples selected for standards development should be genetically homogeneous. The first group should be drawn from the modern elite--in most countries these are the urban educated professionals or managerial people. If possible, a second group from the same ethnic stock who are exposed to deprived economic circumstances should also be included. In all cases, no individual should be included whose age cannot be verified through birth certificates or other documents. When developing cross-sectional standards for persons from birth through age 20, approximately 13 percent of the sample should consist of children up to 1 year old, 5 percent should be from 7 to 8 years old, and 10 percent should be around peak growth velocity (Falkner et al., 1972).

Data Presentation

The presentation of weight and height data for children must be shown according to age, since both of these measures are age-dependent. Weight-for-height is nearly independent of age for children 1 to 10 years old; therefore, ages are not necessary for the data presentation. However, it is customary to show weight-for-height values according to age for groups of children. In adolescence, weight-for-height measurements are influenced by the timing of the growth spurt, making the measure difficult to interpret without data on both chronological and biological age.

The mid-upper-arm circumference and triceps fatfold values are also generally shown according to age, although some authors (Jelliffe and Jelliffe, 1971; Frisancho, 1974) have indicated that mid-upper-arm circumference is relatively age-independent.

Waterlow et al. (1977) recommend that height and weight data should be shown for one-year intervals during the school-age years if at least 100 subjects in each age interval are available. If this is not the case, two-year intervals are recommended. Wider age groupings are permissible when the sample size is small, but they will have limited value in detecting differences in growth patterns. The age intervals should be divided so that a designated age (e.g., six years) represents the full-year age span (i.e., 6.0 to 6.99 years). All data in HES and HANES follow this format. In these surveys, age is defined as the age attained at the child's last birthday. The same procedures are followed for presentation of fatfold and arm circumference data. Since boys and girls enter the growth spurt at different times, and since they show true differences in body composition that are not simply due to differences in body size, all anthropometric data should be reported separately by sex.

There is some controversy whether separate presentations ought to be made according to race or ethnic background. Unless the sample is intentionally stratified by race, sufficient numbers of subjects may not be available to represent the various racial subgroups in the population. However, several investigators have shown differences in height, weight, fatfold and arm circumference data according to race that may not be accounted for by differences in nutritional status. This subject is discussed more fully in the section on anthropometric standards.

The distribution of anthropometric values for various age-sex groups in the sample can be presented in tables or graphs. All anthropometric data show a marked skewness. Consequently, the median rather than the mean is a more appropriate measure of central tendency. Centile values should be used to show the distribution. Typically these are in deciles or quartiles for the sample population. The skewness makes calculation of the standard deviations inappropriate, but Waterlow et al. (1977) show how standard deviation scores can be computed based on median values of a reference population.

Reference Data

A number of studies provide data that meet most of the criteria given by Waterlow et al. for a reference population. All of the national surveys of nutritional status in the United States (i.e., HES, HANES and Ten State) would qualify. HES and HANES also have the advantage of being national probability samples and represent the largest body of anthropometric data ever assembled on children in the United States (NCHS, Ser. 11, No. 165, 1977). Height, weight, and fatfold values for the triceps, subscapular and midaxillary sites for the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles are available for children 6 to 11 years old from Cycle II of HES

(NCHS, Ser. 11, No. 104, 1970; NCHS Ser. 11, No. 120, 1972). These values, plus the suprailiac and medial calf fatfolds, are available for children 12 to 17 years from Cycle III of HES (NCHS, Ser. 11, No. 124, 1973; NCHS, Ser. 11, No. 132, 1974). In addition, tables of the percentile values for mid-upper-arm circumference and arm muscle area for children 6 to 11 years old are available from HES, Cycle II (NCHS, Ser. 11, No. 123, 1973).

Data from the Ten State Nutrition Study have been published by Frisancho (1974). Values for the 5th, 15th, 50th, 85th and 95th percentiles for arm circumference, triceps fatfold, arm muscle diameter, arm muscle circumference and arm muscle area are given, using data from white subjects only. The age intervals used by Frisancho span the mid-point of each year; for example, age six years covers the interval 5.5 to 6.4 years.

Besides these national surveys, several other surveys can be a source of reference data. For example, Tanner and Whitehouse (1962) have published triceps fatfold-for-age for British children. Tanner (1976) has also published mid-arm circumferences-for-age. These two data sets combined with arm-circumference-for-height from the Ten State Nutrition Survey are available on computer tapes from the U.S. Center for Disease Control.

Separate triceps fatfold data for black and white children aged 6 to 13 years in a sample of 1,092 subjects from Philadelphia have been published by Malina (1966). Similar data for the triceps fatfolds of black and white children aged 2 to 15 in the Bogalusa Heart Study have been published by Berenson (1980). These data are presented as smoothed curves for the 5th, 10th, 25th, 50th, 75th and 90th percentiles.

Recently, Zavaleta and Malina (1980) have published height, weight, triceps fatfold and mid-upper-arm circumference values for Spanish-surnamed children of Mexican descent. The sample consisted of 1,269 children aged 6 to 17 years from Brownsville, Texas.

Anthropometric Standards

There are relatively few data sets that meet the criteria set by the IUNS for growth and body composition standards. Currently, the only generally agreed-upon standards for use in the United States are the growth curves constructed for height and weight by NCHS (NCHS, Ser. 11, No. 165, 1977). These curves were first published in 1974. They are derived from the height and weight data collected in HANES and Cycles II and III of HES, and from data collected by the Fels Research Institute in Ohio. The Fels data were used to construct curves for children 0 to 36 months. The curves for children 2 to 18 years of age were constructed from the NCHS data. They consist of separate weight-for-age, height-for-age, and weight-for-height charts for girls and boys. Weight-for-age, and height-for-age cover the entire 2-to-18-year age range. The weight-for-height charts are age-independent, but can be used only for prepubescent boys and girls. NCHS estimates that this includes girls up to 10 years old and boys up to 11-1/2 years old; however, regardless of chronological age, the weight-for-height charts should not be used if the child shows any signs of sexual maturity (Hamill, 1979). No weight-for-height charts were constructed for older children because the variability of timing in the adolescent growth spurt makes it impossible to consider weight-for-height independent of chronological and biological age.

The growth charts give heights (cm) and weights (kg) at the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles for age in each sex. Lines were drawn to connect the centile values at each age to form percentile curves. The curves were smoothed using a computer program developed by de Boor and Rice (the least squares cubic splining technique). Generation of equations and plotting of the curves may be duplicated on any large digital computer with a plotting capability (NCHS, Ser. 11, No. 165, 1977).

The NCHS growth charts can be used as standards for the assessment of nutritional status and to compare groups of children with each other (Hamill et al., 1979). The curves are derived from national probability samples of non-institutionalized U.S. children enjoying the highest standard of living anywhere in the world. A trend towards increasing body size has been noted for many countries in the Western world. From comparisons of data collected in Cycles II and III of HES with HANES data collected almost ten years later, NCHS concludes that the trend in growth ceased to be of sufficient magnitude in the mid 1950s to affect height-for-age data across most socioeconomic levels of American population. Consequently, the NCHS curves can be taken as achievement of full genetic potential by the well nourished children in the population.

There is some controversy in the literature about whether the NCHS growth standards can be applied to non-white children. Since HES and HANES included non-white as well as white children in the sample, a national conference sponsored by the National Institute of Child Health and Human Development concluded that "the use of one standard in the United States for height and weight is unlikely to cause serious errors" (Roche & McKigney, 1976). Tanner (1976) also believes that the same standards can be used for white and black children in the United States, but questions their appropriateness for Asian-Americans. Black and white children, according to Tanner, have similar genetic potentials for height given adequate nutrition, but Asians have different growth patterns, especially in adolescence.

Garn (1979) maintains that there is a need for separate standards according to race on the grounds that leg length contributes different proportions to the total height of whites, blacks and Mexican-Americans. Roche and McKigney (1976) cite Nichaman's opinion that it is inappropriate to use the same weight/height index for all ethnic groups because of this difference in leg length. Zavaleta and Malina (1980) also argue in favor of separate standards for Mexican-Americans.

This controversy will be solved only by continued research on differences in body conformation among racial-ethnic groups. Meanwhile, the argument is largely academic, because separate standards for specific groups do not currently exist. A conservative approach to data analysis, in light of the controversy, is to analyze anthropometric data separately by race. If the sample size is not large enough to permit separation, the effects of race on the distribution of anthropometric values should be controlled in statistical analysis.

Most authorities (e.g., Fomon, 1977; Waterlow et al., 1977; Nichaman & Lane, 1979) recommend that the NCHS growth charts should replace all standards previously used for height and weight. Prior to 1974 the standards most often used to evaluate height and weight of children in the United States were the "Iowa" standards published by Stuart and Meredith (1946). These standards consist of curves for the 10th, 25th, 50th, 75th and 90th percentiles for boys and girls aged 4 to 18 years. For each age and sex group approximately 100 to 200 children were measured. The children all attended the University of Iowa Laboratory schools between 1930 and 1945. Over 90 percent were of northwest European ancestry and their parents were almost exclusively American-born. Approximately 40 percent of the fathers were professional men and 35 percent came from business or management occupations (Martin, 1954). The Stuart-Meredith growth charts met most of the criteria for standards and were appropriate for social and environmental conditions at the time they were developed. However, they covered a limited genetic pool of American children and were developed prior to the cessation of the growth trend.

In addition to the Iowa standards, several other growth charts are available and have been used as standards in studies conducted prior to 1974. These include the Boston or Harvard Growth Charts and the Wetzel Grid.

The Boston Growth Charts are similar in form to the Iowa standards. They were developed by Stuart et al. of the Harvard School of Public Health. The charts show percentile curves for length, height and weight for boys and girls. Length charts are for children 2 to 6 years of age; height charts are for children 6 to 13 years and weight charts span the 2-to-13-year age range. The curves are drawn for the 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles. They were derived from repeated measurements at selected ages on a group of more than 100 white boys and 100 white girls of North European ancestry "living under normal conditions of health and home life" in Boston, Massachusetts, in the 1940s (Stuart & Stevenson, 1954). Similar procedures were followed to construct weight, length, and head circumference charts for infants from birth to 28 months of age.

The Wetzel Grid was originally developed in 1941. The grid consists of three interconnected panels which locate a child with respect to body build (heavy-stocky to thin-light), developmental level for age (high to low), and energy needs. These determinations are made by plotting the child's weight on a vertical scale and the child's height on a horizontal scale. The grid was originally developed by Wetzel from his clinical examinations of school-age children in Cincinnati, Ohio. Another grid was later developed for infants.

The Wetzel grid has been used most extensively in clinics to track the developmental progress of children and to identify individuals needing medical attention. It has not been popular in surveys because it is complicated for untrained personnel to use (Martin, 1954).

Presently, there are no standards for body composition in children. None of the data on body composition measures (i.e., fatfold and circumference measures) mentioned in the previous section can be strictly considered as standards. Currently, a Task Force convened by NCHS is developing curves for triceps and subscapular fatfolds and mid-upper-arm circumferences. These curves are scheduled for preliminary publication in 1981 (NCHS, personal communication). In the absence of more suitable standards, three sets of data have been variously used: (1) the percentile distributions from HES; (2) the Center for Disease Control's compilation of data from the Ten State Survey, Tanner, and Tanner and Whitehouse; and (3) Frisancho's data from the Ten State Survey.

All body composition data derived from population distributions have an inherent problem. Values obtained from surveys may accurately reflect the distribution of adipose versus lean body tissue, but in view of the trend towards obesity in the United States, this distribution may not be "optimum" for health. Currently, there are no standards for judging "optimum" fatfold values or any of the indices derived from fatfolds (such as percent body fat) in children. Until these indices are correlated with health status, all interpretations of body composition standards are somewhat arbitrary.

Assessment of Nutritional Status

The nutritional status of an individual or a population using anthropometric data is assessed in relation to appropriate standards. The comparisons can be made in various ways. As noted in a previous section, the relative weight of an individual can be expressed as a percent of the median value for that person's age and sex. Similar values for a population can be derived by taking the median value of the sample as a percent of the median in the standard population. Relative indices of this kind can also be calculated for height, fatfold values, and arm circumference. Jelliffe (1966) has proposed that individual measurements between 70 and 90 percent of the standards be considered evidence of moderate undernutrition, and measurements below 70 percent be considered evidence of severe undernutrition. A rule of thumb frequently used for obesity is 120 percent of the median weight-for-age. Gray and Kulhanek-Gray (1980) have shown that this approach results in the misclassification of subjects with specific nutritional problems. They contend that comparison of an individual's measurements with percentile values from the standard population is a more accurate means of identifying nutritional problems.

When compared with NCHS growth standards, measurements between the 25th and 75th percentiles in height-for-age, weight-for-age, and weight-for-height are likely to represent normal growth for an individual child (Hamill et al., 1979). In a longitudinal study, crossing percentiles within this range is not atypical unless a downward deviation is progressive before pubescence. Measurements between the 10th and 25th and the 75th and 90th percentiles may or may not be indications of problems, depending on the pattern of earlier growth and on genetic and environmental factors. Values above the 90th and under the 10th percentile constitute nutritional risk, with the greatest risk accorded to the most extreme values (i.e., under the 5th percentile and over the 95th percentile).

The interpretation of weight-for-age as a measure of obesity or leanness is less accurate than weight-for-height. Greater precision is afforded when weight-for-height is combined with fatfold measurements. The 85th percentile is usually chosen as an arbitrary cutoff point for the definition of obesity using the triceps fatfold (Seltzer & Mayer, 1967). Since tables on triceps fatfold from HES do not show the 85th percentile, the 90th percentile has also been used as the cutoff point (Zavaleta & Malina, 1980).

Discussion

Presentation and interpretation of anthropometric data depend upon which of three potential objectives is emphasized in analysis: (1) presentation of sample distributions, (2) comparison of the sample to a reference population, and (3) evaluation of growth and nutritional status. The last two objectives require that distinctions be made between a reference and a standard, where standard implies the achievement of optimum growth.

A number of data sets meet criteria for a reference population but, in the United States, only the growth curves for height and weight developed by NCHS can truly be considered as standards. Cutoff points recommended for judging the risk of under- or overnutrition for individuals and groups are below the 10th percentile and over the 90th percentile, respectively (NCHS, Ser. 11, No. 165, 1977).

No generally recognized standards using fatfold measurements to judge obesity are currently available, but several different sets of reference data can be used for comparative purposes. These data represent population distributions but they may not define optimum nutritional status in relation to health.

CONCLUSIONS

Anthropometric measures include measurements of total body length (height), the length of body segments, weight, circumferences and the thickness of subcutaneous fat measured at various sites. These measures, expressed in relation to age or as various ratios and indices, are used to assess growth and development as reflected by body size and body composition. No single category of measurements (i.e., lengths, weight, circumferences or thicknesses) captures all aspects of growth or development. Therefore, a combination of measures from each category is typically used in nutrition surveys. At the 1968 White House Conference on Food Nutrition and Health, measurement of height, weight, arm circumference and triceps fatfold were recommended for use in evaluations of children through the period of adolescence (Christakis, 1973). Cameron (1978), Jelliffe (1966), Buzina and Veruma (1974), Fomon (1977), and Garn (1979) are among those who support these recommendations, although there is more consensus about height and weight than there is about circumferences and fatfold measures (Waterlow et al., 1977).

In comparison with dietary and biochemical measures of nutritional status, cooperation of subjects poses little problem for measurements of height, weight, circumference and fatfolds using calipers. The major problem in obtaining measurements is in setting up equipment in the field and gaining cooperation when it is necessary for subjects to undress. However, this has been accomplished successfully in several large-scale studies in the United States (e.g., HES, Cycles II and III, HANES).

Reliability problems plague all of the anthropometric measures to some extent. Evaluations of reliability assume that protocols for training, data collection and quality control, such as those described in previous sections of this chapter, are implemented. Yet even with these attempts at standardization, considerable measurement error can occur. Intraindividual variation can also affect the reliability of some anthropometric measures.

Height is subject to some intraindividual variation according to the time of day when measurements are taken and whether subjects are standing or recumbent. Variation in weight measurements can also be considerable, depending on the subject's state of hydration and contents of the bladder and gastrointestinal tract. Zerfas (1979) claims that weight is subject to more intraindividual variation than other anthropometric measures.

The intraindividual variation in fatfold measures using calipers is attributed to differences in fatfold thickness and compressibility at different sites on the body. These factors have less significance when repeated measures are taken on the same individual at any given site, such as the triceps fatfold. In this case, the major component of unreliability is measurement error.

The arm circumference measurement itself has little intraindividual variation; however, measures such as arm muscle circumference and arm muscle area, which are derived from mid-upper-arm circumference and triceps fatfold measures, will show intraindividual variation and measurement error to the extent that the triceps measure is affected by these factors.

Measurement error in anthropometry is partitioned into errors caused by imprecision of the instruments, interobserver differences and intraobserver differences. For most equipment recommended in field surveys, errors of measurement due to imprecision are slight, especially when protocols call for frequent calibration. Most of the error is due to interobserver and intraobserver differences. Fatfold measurements using calipers are subject to greater observer error than the other categories of anthropometric measures. Errors in fatfold measurements are particularly high when subjects are obese. However, ultrasound, which is the only acceptable alternative for large field studies, also shows high rates of observer error. Longitudinal studies should attempt to reduce interobserver error by using the same examiner throughout. If multiple teams of examiners must be used in cross-sectional studies, an attempt should be made to measure the extent to which both inter- and intraobserver error occurs by conducting reliability substudies.

The cost of anthropometric methods depends upon the size of the survey, the precision of equipment, and the expertise of personnel. Very precise automatic scales and height instruments such as those used in HES and HANES are expensive and, depending on the survey budget, may not be affordable if numerous data collection teams are required. Less expensive scales and custom-made height boards have good precision, but the use of multiple teams increases training costs. The need for skilled personnel and specialized equipment for radiography and ultrasound make these two techniques the most expensive of all of the anthropometric methods.

Although cooperation of subjects, reliability, and cost are important criteria to consider when using the various anthropometric measures, perhaps none of these criteria is as critical to the selection process as the validity of the various measures and their derived ratios and indices for determining growth and nutritional status. Table II-7 summarizes major strengths and weaknesses that affect the validity of height, weight, triceps fatfold and mid-upper-arm circumference measures.

The major limitation of the height measurement is that a number of non-nutritional factors affect it. Of these, parental height and racial background are potentially the most confounding factors. These factors must be considered in any explanation of differences in height discovered among groups of children.

The variability of the growth spurt in adolescents complicates the interpretation of both height and weight data on individual children. In both longitudinal and cross-sectional surveys, girls over 10 years old and boys over 11-1/2 years old cannot be accurately evaluated without data on biological as well as chronological age. Without such data it is inappropriate to classify children who lag behind their peers as undernourished.

The major limitation of weight is that the components of weight are not separated into skeletal, muscle and fat tissue. Therefore obesity, which is defined as an excess of body fat, cannot be determined from the weight measurement alone. Expression of weight in relation to height compensates for this deficiency to some extent, but it still does not differentiate muscle from fat. However, a weight-for-height measurement does have the advantage of being independent of age in prepubescent children.

Of the possible ratios of height and weight that have been constructed for obesity, the modified ponderal index (WT/HT^3) appears to be the most valid for school-age children (Frerichs et al., 1979); however, none of the ratios predicts overall body fat as well as fatfold measurements. Since the most valid index may vary according to the population studied, it is recommended

Table II-7. Strengths and Weaknesses Contributing to the Validity of Anthropometric Measures

Measure	Strengths	Weaknesses
Height	● Cumulative long-term measure of protein-calorie nutrition ● Sensitive to nutritional intervention ● U.S. standards available for data interpretation	● Affected by non-nutritional factors ● Difficult to interpret for individuals without data on biological age during adolescence ● May be real differences in growth potential among racial groups
Weight	● Cumulative measure of sufficiency of caloric intake in relation to energy requirements ● U.S. standards available for data interpretation	● Does not separate weight due to skeletal, muscle and fat tissue ● Is only sensitive to nutrition intervention in large groups of subjects ● Shows even greater variability during adolescence than height
Triceps fatfold	● Cumulative measure of obesity ● Sensitive to "preadolescent fat wave" in males ● Is a better predictor than subscapular site of total body fat in obese subjects	● Underestimates subcutaneous fat layer because of compressibility ● Is not the "best" single prediction of total body fat in normal weight subjects ● No U.S. standards currently available ● May be real differences in fat distribution among racial groups
Mid-upper-arm circumference (arm muscle circumference and arm muscle area)	● Cumulative measure of muscle size and protein reserves ● Positively correlated with muscle strength ● Sensitive to nutritional intervention	● Overestimates muscle size in relation to fat when used with triceps fatfold ● Does not account for different sizes of humeri ● Assumes arm is cylindrical in shape

that weight-for-height indices should be empirically tested on the sample in question (DuRant & Linder, 1981).

Fatfold measurements are better predictors of overall body fat than height and weight alone, but the best prediction occurs when all three types of measurements are used. If the absolute amount of fat weight instead of the relative amount (i.e., percent body fat) is of interest, the fatfold measurements should be converted to fat areas (Himes et al., 1980). It is probably unwise to use predictive equations for percent body fat or fat weight that are derived from measurements made on a non-representative sample of children.

No single fatfold measurement is consistently the "best" predictor of body fat. In surveys, the triceps fatfold is usually measured. The triceps fatfold is the best predictor of percent body fat in obese subjects (Seltzer & Mayer, 1967). In addition, the triceps measure can usually be taken without asking subjects to undress.

Mid-upper-arm circumference is of interest because it can be used with the triceps fatfold to obtain an indication of arm muscle circumference and arm muscle area. Both of these indices are limited by the errors resulting from compressibility of the triceps fatfold, and differences in the shape of the arm and thickness of the arm bone. A further limitation of both the triceps fatfold and the arm circumference measures is that while several sets of reference data are available, none of these data sets can be considered as standards. Without supportive data, triceps fatfold and arm circumference measures cannot be used to classify the nutritional status of individuals, but they can be used to compare distributions among groups.

In summary, the studies reviewed in this section support recommendations that height, weight, arm circumference and triceps fatfold measures be used to evaluate the growth and development of school-age children. These measures and the ratios and indices that can be derived from them are the best means available at the present time to evaluate the sufficiency of protein and calorie intake of children on a cumulative, long-term basis. Nevertheless, each measure is subject to limitations that affect the interpretation of anthropometric data from both cross-sectional and longitudinal studies. Investigators must therefore take precautions in the sample design, data collection, training, quality control and data analysis to maximize the reliability and validity of results.

RECOMMENDATIONS

The review of literature indicates that no single method can give a complete picture of the nutritional status of children. A combination of different methods must be used, depending on the objectives of the study. The evaluation of school nutrition programs is not meant to be an assessment of nutritional status *per se*; rather, it is an assessment of the potential impacts of programs on the nutritional status of participants. Furthermore, for most American children, the various programs do not serve as interventions to correct prior nutritional deficiencies. They are designed to fulfill a broader mandate to "safeguard the health of school children." The selection of methods for the nutritional assessment of program impacts should be guided by results of prior studies and should be based on an estimate of the parameters that are most likely to show the benefits of program participation, given certain feasibility and cost constraints.

In light of these facts, it is concluded that dietary methods offer the best possibility of determining program impacts in a cross-sectional study. The 24-hour recall is the method of choice. The contribution of school meals to the 24-hour intake of participants can be examined and comparisons of average daily intakes of nutrients can be made between participants and nonparticipants of the various programs on the day of the recall. The 24-hour recall can also supply information about food consumption patterns to assess intakes of foods containing fiber, fat, cholesterol, sugar and salt that are known or are suspected to be related to specific health problems.

Dietary assessments can also be included in longitudinal studies. If the objective is to classify the intake of individuals and monitor changes over time, the dietary history method should be used, since it provides a more valid picture of usual habits. Attempts to determine the adequacy of dietary intake for individuals should be accompanied by clinical, anthropometric and biochemical data.

These dietary assessments are recommended because, from the viewpoint of prevention, they represent the strongest evidence that the school nutrition programs are targeted to the nutritional needs of children and provide the quality and quantity of foods that "safeguard" school children's health.

Anthropometric measurements should also be included in studies of school nutrition impacts. While these measures are affected by factors other than nutrition, they are sensitive to both nutritional deprivation and excess and probably constitute the best available overall index of long-term nutritional status. Examination of anthropometric measures can therefore provide indications of the benefits of long-term participation in school nutrition programs that cannot be obtained merely by looking at 24-hour dietary intake.

In longitudinal studies, anthropometric measures can monitor changes in growth or development that result from program participation. However, unless the subjects are malnourished at the onset of the study, it may not be reasonable to expect changes beyond those that would normally occur over the time span of the study. Prior growth histories of the children would be needed to make this determination. Also, if the study includes adolescent subjects, examinations should be performed to determine biological age.

Biochemical methods have less to offer in terms of demonstrating program impacts in cross-sectional studies. Iron deficiency is believed to be a common problem in the school-age population, but previous studies using hemoglobin or hematocrit measures have failed to demonstrate effects of program participation on iron status. Serum ferritin is a more sensitive measure, but the likelihood of showing program impacts using this measure must be balanced against the costs of blood sample collection and analysis as well as the possibility that school districts or parents may refuse to give permission for the children to participate.

Studies reviewed in Chapter III suggest that deficiencies of nutrients such as vitamin A and zinc may affect some subgroups of school-age children; however, the added costs of conducting biochemical tests of these nutrients in a cross-sectional survey are not justified. The prevalence of deficiencies is too low in the general population to expect that differences could be ascribed to program participation. The fact that some tests reflect short-term dietary intake while other tests reflect more long-term status adds to the problem of interpreting results.

Biochemical methods could be used effectively in longitudinal studies. If the design is a prospective intervention trial, biochemical tests would be the most sensitive of all nutritional assessment methods to identify children at nutritional risk who potentially could benefit from participating in school nutrition programs. However, in this case there would be strong ethical pressures against withholding medical treatment to children with the diagnosed nutritional deficiencies. Consequently, it would be difficult to obtain an unconfounded biochemical measure of program effects at the end of the study.

SUMMARY OF CHAPTER III

THE NUTRITIONAL STATUS OF SCHOOL-AGE CHILDREN

This chapter summarizes the literature on the nutritional status of school-age children in the United States. It is limited to relevant large-scale national surveys and to selected local studies in which nutritional status was evaluated in terms of dietary, biochemical, anthropometric, and clinical findings.

Symptoms and signs of classicial nutritional deficiency diseases are not common among school-age children in the United States. Malnutrition in this country consists largely of subclinical nutrient deficiencies or overnutrition, with consequences evident only in long-term impairments to the health status of the population, as in the increased prevalence of nutrition-related chronic diseases such as cancer, diabetes and cardiovascular disease.

In order to identify the extent of malnutrition among school-age children in the United States, several questions have guided the literature review and have structured the presentation of our findings. The major question which this review addresses is the following:

WHAT NUTRITIONAL PROBLEMS ARE FOUND AMONG SCHOOL-AGE CHILDREN, AND HOW ARE THESE PROBLEMS RELATED TO DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS?

To answer this question, several subquestions were composed, and the literature pertinent to each was reviewed. The subquestions and the major findings of our review are summarized below.

A. *What Dietary Deficiencies and/or Excesses of Nutrients and Other Dietary Constituents Have Been Identified as Nutritional Problems of School-Age Children?*

Large proportions of children in certain subgroups have dietary intakes of nutrients that fall below standards. In the absence of biochemical and/or clinical symptoms, the significance of such dietary deficiencies is difficult to judge; however, for purposes of health promotion it can be said that children would be better off if their nutrient intakes were improved. Nutrients that are most often found to be deficient include iron, calcium, vitamin A, and vitamin C. Limited data also suggest that nutrients for which Recommended Dietary Allowances have been established in more recent years should receive attention in future studies. The Nationwide Food Consumption Survey (USDA, SEA, 1980) shows that relatively large numbers of children, particularly adolescent females, fall short of dietary standards for vitamin B_6 and magnesium. Other local surveys have shown that intakes of folic acid and trace minerals such as copper and zinc are low in some school-age groups (Greger et al., 1978).

Nutrient intakes of most children are associated with socioeconomic status. All of the national surveys and most of the local studies found that greater proportions of low-income children fail to meet dietary standards than children from upper income groups. These deficiencies are usually related to differences in the total calorie-value of the diet, indicating that an inadequate quantity of food rather than poor food choices is the reason why low-income children consume fewer nutrients.

Racial differences have also been discovered. For example, black children typically consume less calcium (Abraham et al., 1974) and riboflavin (Lee, 1978; Lopez et al., 1980) than white children. Differences in milk consumption may be related to these patterns (Lopez et al., 1980).

Not many studies have measured the dietary intake of fat, cholesterol, sugar and salt in children's diets. These dietary constituents are of interest because excessive intakes are thought to be related to the onset of diseases such as heart disease, diabetes and cancer. The National Food Consumption Survey found that while fat intakes of children have decreased in recent years, fat still constitutes 37 to 40 percent of total calories. This level is higher than the 35 percent recommended by some authorities (National Research Council, 1980).

Children are large consumers of foods that contain high amounts of sugar and salt. HANES, the National Food Consumption Survey, and several of the local studies found that large proportions of children consume soft drinks, desserts and salty snack foods on a daily basis.

Food consumption patterns of children have also been shown to contribute to obesity. One study found a relationship between caloric intake and the frequency of eating during the day (Frank et al., 1978). In this study, children were found to consume approximately one-third of their daily energy in between-meal snacks. This suggests that snacking habits of children may be as important a cause of obesity as food consumed at regular meals. However, it also appears that meal skipping is common, especially among female adolescents (USDA, 1980).

B. *What Nutrition-Related Conditions Have Been Identified by Biochemical Techniques as Potential Problems for School-Age Children?*

Iron deficiency anemia is considered to be a prevalent nutritional problem of children in the United States. In the Ten State Nutrition Survey and HANES the highest prevalence of low hemoglobin values was found among low-income blacks. Older children were generally found to have a higher prevalence of low hemoglobin values. According to Dallman et al. (1978), the prevalence of iron deficiency anemia in black children may be over-estimated by as much as

10 percent because black individuals generally have lower hemoglobin levels than whites regardless of socioeconomic status.

Other measures such as serum iron, transferrin saturation and serum ferritin give a better picture of iron status. No school-aged population in HANES had a prevalence of low serum iron values greater than 5 percent. The highest prevalence of low transferrin saturation among 6 to 11 year olds was 17.7 percent among low-income whites. In children aged 11 to 17 years, the highest prevalence of low transferrin saturation was 12.5 percent in low-income blacks. Females had a higher prevalence of low values than males. Serum ferritin was not measured in either the Ten State Survey or HANES.

These data lead to the conclusion that while the exact prevalence of anemia may be difficult to estimate, significant numbers of school-age children have low iron stores as evidenced by low transferrin saturation. Female adolescents constitute the group at greatest risk.

Deficiencies of other nutrients based on biochemical measurements have been noted in selected subgroups. For example, low serum vitamin A has been observed among low-income Mexican-American children (Ten State Nutrition Survey; Larson et al., 1974). The Ten State Survey and two smaller studies (Lee, 1978; Prothro et al., 1976) found that more black children had low serum vitamin A levels than whites.

Low-income children, especially Hispanics and blacks, may also be in poor riboflavin status. Low riboflavin values were found in 32 percent of children from low-income states in the Ten State Survey and 10 to 34 percent in two samples of low-income children in New York City (Lopez et al., 1975; 1980). These findings are difficult to understand in view of the fact that riboflavin intakes of low-income children are generally at or above standards in most of the surveys.

Serum cholesterol values are of interest because high levels in adulthood constitute a risk factor for cardiovascular disease. Most surveys, including the Health and Nutrition Examination Survey, have found that average values among school-age children are within normal limits. However, some studies have found that 15 percent or more children have serum cholesterol levels greater than 200 mg/dl (Hodges & Krehl, 1965; Christakis et al., 1967). In most studies, black children are found to have higher levels than whites (e.g., Frerichs et al., 1977; Lee, 1978).

Other nutrients have not been studied extensively by biochemical means. Limited information suggests that folic acid (Van de Mark & Wright, 1972) and vitamin B_6 (Kirksey et al., 1978) may be problems for adolescent females. Not enough is known about trace minerals such as copper and zinc to draw conclusions about their status in school-age children.

C. *What Growth and Development Problems Have Been Identified by Anthropometric Methods as Nutritional Problems of School-Age Children?*

Growth retardation has been documented for children of low socioeconomic status. The best available estimates indicate that more than 5 percent of such children are below the 5th percentile for height-for-age. Children from low-income families are more likely to exhibit reduced height and weight for age than children from families with higher incomes. These conclusions have been reached by comparing all low-income children to the same standards. Most of the standards used in the surveys were derived from samples of white children, and ethnic differences are often not taken into account. When children are matched for income, black children tend to be taller and heavier than their white counterparts. The magnitude of these differences varies with age and sex. Since specific standards for evaluation of anthropometric data do not exist for ethnic groups, the extent of growth retardation may be underestimated for some ethnic groups and overestimated for others.

More children may be at risk from overconsumption than are at risk from underconsumption of food. Anthropometric data show trends toward obesity in the child population that increase with age. Some studies (e.g., the Ten State Survey) have found that as many as 10 percent of children between 6 and 11 years old are obese. There are relationships between obesity and sex, race, and socioeconomic status, but they have not been consistent among all studies. Generally there is a trend for greater obesity among children from upper income groups. The exception is low-income black females. During late adolescence and adulthood this group shows greater numbers with obesity than any other subgroup in the population. The growing numbers of obese children are of concern because research indicates that obese children have a high probability of becoming obese adolescents and obese adults (Zack et al., 1979; Weil, 1977). In adulthood, obesity aggravates or accompanies conditions such as high blood pressure and diabetes (Bray, 1979).

D. *What Clinical Signs of Nutritional Problems Have Been Identified Among School-Age Children?*

Symptoms of classical nutritional deficiency diseases are not common among school-age children in the United States. The low prevalence of clinical signs does not diminish the serious nature of such nutritional deficiencies when they are seen; nevertheless, it leads to the conclusion that malnutrition in this country is largely subclinical and of chronic duration. The consequences are more evident in the long-term health status of the population than in the incidence of acute disorders.

Conditions such as cardiovascular disease may begin in childhood, but may not result in a health impariment until later in life. Elaboration of the relationships between high blood pressure, which is seen with surprising frequency in the school-age population (Lauer et al., 1975), and dietary factors such a sodium intake and obesity, is an especially high priority for further research.

Dental caries is another nutrition-related problem of concern in the school-age population. The Ten State Survey found a high prevalence of dental caries in both high- and low-income states; in the low-income states more decayed teeth were unfilled. The Ten State Survey also showed that, among school-age children, the prevalence of dental caries was significantly related to the amount of carbohydrate consumed in between-meal snacks (Center for Disease Control, 1972).

CHAPTER III. NUTRITIONAL STATUS OF SCHOOL-AGE CHILDREN

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INTRODUCTION

The nutritional status of school-age children is influenced by a number of factors, such as diet, growth rate, hormonal activity, previous health status, present health status, and environment, among others. While extensive nutritional deficiencies are uncommon among the school-age population of the United States, it may be complacent to believe that all school-age children are well fed.

The purpose of this chapter is to provide an overview of nutritional problems affecting school-age children in the United States. Nutritional problems may be detected by dietary data analysis, biochemical tests, anthropometric measurements, and clinical examinations. The most appropriate method in any situation depends on the nature, extent, and severity of the nutritional problems. The application of these methods, with guidelines for interpretation of the findings, is discussed in Chapter II. The review of literature in the following sections of this chapter is organized in terms of the following questions.

A. *What Dietary Deficiencies and/or Excessive Intakes of Nutrients and Other Dietary Constituents Have Been Identified as Nutritional Problems of School-Age Children?*

B. *What Nutrition-Related Conditions Have Been Identified by Biochemical Techniques as Potential Problems for School-Age Children?*

C. *What Growth and Development Problems Have Been Identified by Anthropometric Measures of Nutritional Status Among School-Age Children?*

D. *What Clinical Signs of Nutritional Problems Have Been Identified Among School-Age Children?*

No large-scale studies have surveyed school-age children exclusively; however, several nationwide as well as local studies have included children from this age group in their samples. The large-scale national surveys that have assessed some aspect of the nutritional status of the U.S. population and have included school-age children as part of their sample are the Ten State Nutrition Survey (Center for Disease Control, 1972), the Health and Nutrition Examination Survey (HANES, 1971-1974), the Nutrition Surveillance System (Nichaman & Lane, 1979) and the Nationwide Food Consumption Survey (USDA, SEA, 1979, 1980; Pao, 1979).

The Ten State Nutrition Survey was initiated in 1968 to

> make a comprehensive survey of the incidence and location of serious hunger and malnutrition and health problems incident thereto in the United States (p.1-1).

This survey was the first large-scale attempt to assess the nutritional status of the United States population. Data were collected between 1968 and 1970. The sample was drawn from ten states--California, Kentucky, Louisiana, Massachusetts, Michigan, New York, South Carolina, Texas, Washington, and West Virginia. The sample was intended to be representative of the low-come population. It was obtained by sampling households in districts that had the lowest income levels in each state according to the 1960 census. Not all of the subjects who participated in the survey were low-income, however, since many middle and upper-income individuals also lived in the selected districts.

The Health and Nutrition Examination Survey (HANES) supersedes the Health Examination Survey (HES) administered by the National Center for Health Statistics (NCHS). HES was a periodic survey that focused on health status, while HANES will measure both the health status and the nutritional status of the United States population and will monitor changes in this status over time. HANES is the first survey of nutritional status that uses a scientifically designed sample permitting estimates to be made for the entire United States.

HES Cycle I examined a national probability sample of 6 to 11 year olds and focused on growth and development. Over seven thousand (7,199) individuals were examined from 1963 to 1965, representing a total of 24 million children aged 6 to 11 in the U.S. HES Cycle II examined youth 12 to 17 years of age from 1966 to 1970. Over six thousand (6,768) individuals were examined, of whom nearly one-third had previously been included in Cycle I. Both surveys included anthropometric measurements (height, weight, fatfold, etc.) and indices of skeletal and sexual maturation.

The first cycle of HANES was conducted in 1971-74 and consisted of a national probability sample of persons between 1 and 74 years of age, excluding persons living on reservations and in institutions. Further details of the HES and HANES samples are provided in Chapters II and IV.

The Center for Disease Control's Nutrition Surveillance System was initiated in 1973 in five states: Arizona, Kentucky, Louisiana, Tennessee, and Washington. The CDC System now includes approximately 20 states (Nichaman, Personal Communication, January, 1981). The goals of the program are

> ...to identify pockets of poor nutritional status, monitor changes in variables which will predict deterioration of nutritional status, and ultimately to improve the health status of individuals (Nichaman & Lane, 1979, p. 410).

Four nutritional status measures are monitored: height, weight, hemoglobin, and hematocrit. These measures are obtained from individuals who attend public health clinics in each of the states. Since the data are not obtained from a survey sample drawn specifically for health and nutritional assessment, the findings are not necessarily representative of the nation or of the states in the system. However, they do consitute a large body of current information on the school-age population.

The final national survey to be discussed here is the most recent National Food Consumption Survey (1977-1978), which is the sixth in a series of surveys conducted by USDA since 1936. It includes 15,000 households from the 48 coterminous states, or approximately 34,000 individuals. Supplemental surveys cover persons in Puerto Rico, Hawaii, and Alaska; persons over 65 years of age; and persons participating in the Food Stamp Program.

Using a combination of record and recall methods, the survey attempts to provide information on household and individual food consumption patterns. At the time of preparation of this manuscript, only preliminary reports from this survey had appeared (USDA, SEA, 1979, 1980, 1981).

In addition to these major national surveys, numerous local surveys of the nutritional status of school children have also been conducted. Some of these are long-term, on-going studies such as those in Bogalusa, Louisiana; Evans County, North Carolina; Framingham, Massachusetts; Muscatine, Iowa; Princeton School District, Cincinnati, Ohio; and Tecumseh, Michigan. Others are single-point prevalence surveys. While it is not possible to draw conclusions from these studies for the total school-age population, these local surveys supplement the data from the nationwide surveys and help to identify problems in subgroups of the school-age population. Tables III-5, III-6, III-8, and III-9 summarize all of the national surveys and a large number of the local nutrition surveys. The authors, year of publication, sample size and characteristics, and major nutritional findings are presented, with comments and conclusions. Surveys are listed by author in alphabetical order.

A. *What Dietary Deficiencies and/or Excessive Intake of Nutrients and Other Dietary Constituents Have Been Identified as Nutritional Problems of School-Age Children?*

A large amount of information has been collected on the dietary intake of school-age children in the United States. Three nationwide surveys have inclued dietary assessments: Ten State Nutrition Survey (TSNS), Health Examination and Nutrition Survey (HANES), and National Food Consumption Survey (NFCS). In addition, numerous smaller investigations have been conducted on children of various ages, ethnic backgrounds and income levels living in different parts of the country.

Most of the studies that collected dietary information used the 24-hour recall method. However, some researchers used diet histories (O'Neill et al., 1976); food records (Hard et al., 1958; Van de Mark & Wright, 1972); a combination of methods (Burroughs & Huenemann, 1970); or other instruments (Hodges & Krehl, 1965; Myers et al., 1968). The strengths and weaknesses of these various methods of collecting dietary data are discussed in Chapter II.

Dietary surveys report low, excessive, or unbalanced nutrient intakes, which are generally expressed as the difference between observed consumption and a suggested allowance. In the United States, most data are compared with the Recommended Dietary Allowance (RDA), which are periodically published by the Food and Nutrition Board of the National Research Council. While the latest RDA were published in 1980, much of the research reviewed here used the 1974 edition or earlier editions of the RDA. (The 1980 RDA are given in Table II-2, Chapter 2. For comparison, the 1974 RDA are given in Table III-1.)

Some researchers construct their own standards for dietary analysis instead of using the RDA. For example, both TSNS and HANES used standards that were designed especially for the surveys. The HANES standards are shown in Table III-2. These standards were developed by an advisory group that considered recommendations made by the World Health Organization, the National Research Council, and other authorities (Abraham et al., 1974).

In the following review of studies of the dietary intake of school-age children, it must be kept in mind that vitamin and mineral supplements are usually not included in the nutrient analyses. This means that the actual ingestion of some vitamins or minerals may be higher than results calculated from food intake data alone would indicate. On the other hand, nutrient losses from exposure to heat and light as a result of improper handling of food are also not included.

Energy (Calories)

Human beings receive the energy for both internal body functions and physical activity from the carbohydrate, fat, and protein in food. Alcohol also provides energy. The energy content of food and alcohol is measured in kilocalories, often shortened to "Calories."

There are three major classes of energy nutrients: proteins, carbohydrates, and fats. Most natural foods contain all three nutrients in different proportions. Protein is a constituent of every living cell. Thus it is a very important nutrient for building body tissues as well as providing energy. Carbohydrates can be either in a complex form as starch or in a simpler form as sugar. Both starch and sugar are metabolized to form glucose, which is the form of carbohydrate used to produce energy. Fats also produce energy and aid in the absorption of fat-soluble vitamins A, D, E, and

Table III-1. Food and Nutrition Board, National Academy of Sciences-National Research Council Recommended Daily Dietary Allowances, Revised 1974

	Age	Weight		Height			Fat-Soluble Vitamins			Water-Soluble Vitamins							Minerals					
	(years)	(kg)	(lb)	(cm)	(in)	Protein (g)	Vitamin A (μg RE)[b]	Vitamin D (μg)[c]	Vitamin E (mg α-TE)[d]	Vitamin C (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg NE)[e]	Vitamin B-6 (mg)	Folacin[f] (μg)	Vitamin B-12 (μg)	Calcium (mg)	Phosphorus (mg)	Magnesium (mg)	Iron (mg)	Zinc (mg)	Iodine (μg)
Infants	0.0–0.5	6	13	60	24	kg × 2.2	420	10	3	35	0.3	0.4	6	0.3	50	0.3[g]	360	240	50	10	3	40
	0.5–1.0	9	20	71	28	kg × 2.0	400	10	4	35	0.5	0.6	8	0.6	45	1.5	540	360	70	15	5	50
Children	1–3	13	29	90	35	23	400	10	5	45	0.7	0.8	9	0.9	100	2.0	800	800	150	15	10	70
	4–6	20	44	112	44	30	500	10	6	45	0.9	1.0	11	1.3	200	2.5	800	800	200	10	10	90
	7–10	28	62	132	52	34	700	10	7	45	1.2	1.4	16	1.6	300	3.0	800	800	250	10	10	120
Males	11–14	45	99	157	62	45	1000	10	8	50	1.4	1.6	18	1.8	400	3.0	1200	1200	350	18	15	150
	15–18	66	145	176	69	56	1000	10	10	60	1.4	1.7	18	2.0	400	3.0	1200	1200	400	18	15	150
	19–22	70	154	177	70	56	1000	7.5	10	60	1.5	1.7	19	2.2	400	3.0	800	800	350	10	15	150
	23–50	70	154	178	70	56	1000	5	10	60	1.4	1.6	18	2.2	400	3.0	800	800	350	10	15	150
	51+	70	154	178	70	56	1000	5	10	60	1.2	1.4	16	2.2	400	3.0	800	800	350	10	15	150
Females	11–14	46	101	157	62	46	800	10	8	50	1.1	1.3	15	1.8	400	3.0	1200	1200	300	18	15	150
	15–18	55	120	163	64	46	800	10	8	60	1.1	1.3	14	2.0	400	3.0	1200	1200	300	18	15	150
	19–22	55	120	163	64	44	800	7.5	8	60	1.1	1.3	14	2.0	400	3.0	800	800	300	18	15	150
	23–50	55	120	163	64	44	800	5	8	60	1.0	1.2	12	2.0	400	3.0	800	800	300	18	15	150
	51+	55	120	163	64	44	800	5	8	60	1.0	1.2	13	2.0	400	3.0	800	800	300	10	15	150
Pregnant						+30	+200	+5	+2	+20	+0.4	+0.3	+2	+0.6	+400	+1.0	+400	+400	+150	h	+5	+25
Lactating						+20	+400	+5	+3	+40	+0.5	+0.5	+5	+0.5	+100	+1.0	+400	+400	+150	h	+10	+50

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[a] The allowances are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods in order to provide other nutrients for which human requirements have been less well defined. See text for detailed discussion of allowances and of nutrients not tabulated. See Table 1 (p. 20) for weights and heights by individual year of age. See Table 3 (p. 23) for suggested average energy intakes.

[b] Retinol equivalents. 1 retinol equivalent = 1 μg retinol or 6 μg β carotene. See text for calculation of vitamin A activity of diets as retinol equivalents.

[c] As cholecalciferol. 10 μg cholecalciferol = 400 IU of vitamin D.

[d] α-tocopherol equivalents. 1 mg *d*-α tocopherol = 1 α-TE. See text for variation in allowances and calculation of vitamin E activity of the diet as α-tocopherol equivalents.

[e] 1 NE (niacin equivalent) is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

[f] The folacin allowances refer to dietary sources as determined by *Lactobacillus casei* assay after treatment with enzymes (conjugases) to make polyglutamyl forms of the vitamin available to the test organism.

[g] The recommended dietary allowance for vitamin B-12 in infants is based on average concentration of the vitamin in human milk. The allowances after weaning are based on energy intake (as recommended by the American Academy of Pediatrics) and consideration of other factors, such as intestinal absorption; see text.

[h] The increased requirement during pregnancy cannot be met by the iron content of habitual American diets nor by the existing iron stores of many women; therefore the use of 30–60 mg of supplemental iron is recommended. Iron needs during lactation are not substantially different from those of nonpregnant women, but continued supplementation of the mother for 2–3 months after parturition is advisable in order to replenish stores depleted by pregnancy.

Table III-2. Standards for Evaluation of Daily Dietary Intake Used In the Health and Nutrition Examination Survey, United States, 1971-72

	Calories (per kg)	Protein (gm per kg)	Calcium (mg)	Iron (mg)	Vitamin A* (I.U.)	Vitamin C (mg)
1-5 years:						
12-23 months, male and female	90	1.9	450	15	2000	40
24-47 months, male and female	86	1.7	450	15	2000	40
48-71 months, male and female	82	1.5	450	10	2000	40
6-7 years, male and female	82	1.3	450	10	2500	40
8-9 years, male and female	82	1.3	450	10	2500	40
10-12 years - Male	68	1.2	650	10	2500	40
- Female	64	1.2	650	18	2500	40
13-16 years - Male	60	1.2	650	18	3500	50
- Female	48	1.2	650	18	3500	50
17-19 years - Male	44	1.1	550	18	3500	55
- Female	35	1.1	550	18	3500	50
20-29 years - Male	40	1.0	400	10	3500	60
- Female	35	1.0	600	18	3500	55
30-39 years - Male	38	1.0	400	10	3500	60
- Female	33	1.0	600	18	3500	55
40-49 years - Male	37	1.0	400	10	3500	60
- Female	31	1.0	600	18	3500	55
50-54 years - Male	36	1.0	400	10	3500	60
- Female	30	1.0	600	18	3500	55
55-59 years - Male	36	1.0	400	10	3500	60
- Female	30	1.0	600	10	3500	55
60-69 years - Male	34	1.0	400	10	3500	60
- Female	29	1.0	600	10	3500	55
70 years and over - Male	34	1.0	400	10	3500	60
- Female	29	1.0	600	10	3500	55
Pregnancy (fifth month and beyond), add to basic standard	200	20	200		1000	5**
Lactating, add to basic standard	1000	25	500		1000	5

*Assumed 70 percent carotene, 30 percent retinol.
**For all pregnant women.

K. Compared with protein and carbohydrate, fats are a more concentrated source of energy. One gram of fat produces nine calories, while one gram of protein or carbohydrate produces four calories. Alcohol produces seven calories per gram.

As shown in Table III-3, the NFCS provides estimates of the percentages of total energy supplied by carbohydrate, protein and fat in the diets of school-age children (USDA, SEA, 1980). Data from many of the more recent local studies tend to agree with the national data. For example, Frank et al. (1978) found that children in Bogalusa, Louisiana consume 13 percent of their total calories from protein, 39 percent from fat, and 49 percent from carbohydrate.

Some studies show racial differences in fat consumption. For example, a study by Lee (1978) among teenagers in Kentucky found that black males obtained more of their calories from fat than white males (i.e., 46% vs 42%), but that white females obtained more of their calories from fat than black females (i.e., 40% vs 38%).

There is no specific recommendation for the proportion of energy that should come from protein, carbohydrate or fat. However, because some research has associated high levels of fat in the diet with heart disease, some forms of cancer, and other health conditions, most authorities recommend that Americans should moderate their fat intake. The National Research Council suggests a guideline of 35 percent of calories from fat--especially for individudals consuming less than 1000 calories per day (National Research Council, 1980). It appears that average intakes of fat among American school children exceed this guideline, especially among adolescent males, who consume approximately 41 percent of their calories from fat. USDA data show, however, that average fat intakes have decreased since 1965 (when the last Food Consumption Survey was performed). Some of the earlier local studies

Table III-3. Percent of Total Calories From Protein, Fat and Carbohydrate for School-Age Children

Sex and Age (Years)	Protein	Fat	Carbohydrate
Males and females			
6-8	15.6	37.6	47.8
Males			
9-11	15.8	38.8	46.1
12-14	15.5	39.9	45.5
15-18	16.0	40.6	44.0
Females			
9-11	15.4	37.4	48.3
12-14	15.5	39.3	46.0
15-18	16.1	39.6	44.8

Note: From National Food Consumption Survey (USDA, SEA, 1980)

bear this out. For example, Hodges and Krehl (1965) found that teenagers in Iowa received 43.5 percent of their total energy from fat.

Milk and meat appear to be the primary sources of fat in children's diets (USDA, SEA, 1980; Frank et al., 1978); however, animal sources provide only one-third more fat than vegetable sources (Frank et al., 1977). Sugar intake, mainly in the form of sucrose, provided 25 percent of the total energy intake of Bogalusa children studied by Frank et al. (1977).

Total energy intake in the National Food Consumption Survey was compared with the 1980 RDA. Since the 1980 RDA give ranges of energy intakes for various age-sex groups, the midpoint of the range was used for computations. Children 6 to 8 years of age had average intakes that were 81 percent of the standard; intakes of older children ranged from 80 to 96 percent for males and 80 to 87 percent for females. These intakes are not necessarily inadequate; individuals vary greatly in their energy requirements, depending on metabolic factors and physical activity.

The findings of all three major U.S. surveys indicate that children from low-income households consume fewer calories than children from upper income households. In the NFCS, children from homes with less than $6,000 annual income had lower percentages of the RDA for calories than the national average in every age-sex group. Both TSNS (Lowe et al., 1975) and HANES (Abraham et al., 1974) found that the energy intake of school-age children in all age, sex and ethnic groups was associated with family income. One reviewer who examined the Ten State data concluded that among low-income persons, the quantity of food intake, rather than the quality, was the major dietary problem highlighted by the survey (Lowe et al., 1975).

Ethnic differences in caloric intake were also observed, but it is difficult to separate this factor from socioeconomic factors. However, in HANES, white children from the income group above poverty had the highest caloric intakes, while black children in the income group below poverty had the lowest caloric intakes, at all ages and in both sexes. The magnitude of the difference was generally such that the lower value for low-income blacks was approximately 80 percent of the higher value for upper-income whites (Abraham et al., 1974).

Local studies generally parallel the findings of the national surveys. Lee (1978) found a large proportion of low-income teenagers in Kentucky with energy intakes below 67 percent of the 1974 RDA; so did Frank et al. (1977) for a population of 10- to 14-year-old children in Louisiana. Both of these samples contained black and white children.

There are also indications that children from other ethnic minority groups have lower-than-average energy intakes. Energy intake data on 20 children in California, ages 6 to 9, most of whom were Mexican-American, showed that 25 percent consumed less than 80 percent of the RDA (Burroughs & Huenemann 1970). The average energy intakes of 298 Mexican-American children from the lower Rio Grande Valley of Texas fell below the RDA in a study by Larson et al. (1974). The Ten State Survey also found that Spanish-American children in New York City, California, and Texas were apt to have low energy intakes (Center for Disease Control, 1972).

Protein

Because protein is required for the synthesis of body tissue, inadequate intakes of protein could potentially have detrimental effects on the growth and development of children. Both the amount and quality of protein in the diet are important. Proteins from animal sources are closer in composition to human requirements, but diets composed of proteins from vegetable sources can be adequate, provided that a sufficient quantity or combination of vegetable protein foods is consumed.

Findings from the NFCS, HANES and TSNS indicate that protein intakes of school-age children are adequate. In a review of the nationwide surveys, Owen and Lippman (1977) state that mean protein intakes per 1000 kilocalories show little or no variance by ethnicity or socioeconomic factors. While there are variations in the relative proportion of animal and vegetable sources of protein in the diet among ethnic and regional groups, there is no evidence that the nutritional quality of the protein is inadequate. The NFCS showed that even in households with incomes below $6,000 per year, children consumed between 122 and 207 percent of their RDA for protein (USDA, 1980). The majority of the local studies that assessed the dietary protein intake of school-age children also found that it met or exceeded the RDA (Hodges & Krehl, 1965; Larson et al., 1974; Burroughs & Huenemann, 1970; Frank et al., 1977, 1978).

9

Cholesterol

Cholesterol belongs to the family of chemical substances called lipids. This family of substances also includes dietary fats, but cholesterol, unlike fat, does not produce calories. Under normal circumstances, cholesterol performs a number of helpful functions in the body, such as participating in the manufacture of hormones, vitamin D and bile acids which are needed for the digestion and absorption of fat. There is interest in the dietary intake of cholesterol because high intakes have been associated with heart disease in some epidemiological studies. The desirable intakes of cholesterol for children and adults are controversial. Some recommendations have been made to limit cholesterol to 300 mg per day (U.S. Select Senate Committee on Nutrition and Human Needs, 1978) but this level is not accepted by all authorities.

There are only a few studies that have assessed the cholesterol intakes of children. Frank et al. (1977, 1978) reported cholesterol intakes of school-age children in Bogalusa and Franklinton, Louisiana. Average intake of 9 to 11 year olds in Bogalusa was 324 mg per day. Children in Franklinton between 10 and 14 years of age averaged 345 mg of cholesterol per day. The majority of children in both samples were black.

Lee (1978) obtained data from 118 teenagers--85 white and 33 blacks. Mean intakes ranged from 263 mg for black females to 475 mg for white males.

None of the national surveys report cholesterol intakes.

Vitamins

Vitamins are organic compounds that are necessary in small amounts in the diets of higher animals for growth, reproduction, and maintenance of normal health. Fourteen vitamins have been identified up until now (Briggs & Calloway, 1979). Only those that have been investigated in surveys as being of concern to the school-age population of the United States will be discussed here.

Vitamin A. Vitamin A is essential for growth, vision (including the ability to see well in dim light), tooth development, and maintenance of epithelial tissues. The major dietary sources of this vitamin are liver, butterfat, and egg yolks. Certain plant constituents (carotenes) can be converted into vitamin A in the body; these are found in dark green (e.g., spinach) and deep yellow (e.g., carrots) vegetables. In the United States, vegetable sources provide almost half the daily intake of vitamin A (Greenwood & Richardson, 1979). However, according to the NFCS (USDA, SEA, 1980) school-age children obtain most of their vitamin A from milk and grain products. Greenwood and Richardson (1979) state that the average diet in the United States is so rich in vitamin A or in provitamin A substances that it should provide approximately twice the recommended allowance for this vitamin. Even though the NFCS found that vitamin A intakes of all age groups declined between 1965 and 1977, average intakes in the more recent surveys were over 100 percent of the RDA in all age-sex groups of school-age children.

Vitamin A intakes were also generally adequate in HANES. In all but one age-sex group, black and white children above and below poverty had mean intakes above 100 percent of the standard. The exception was black females age 12 to 17 years, who were in the above-poverty group (Abraham et al., 1974). It should be noted, however, that the HANES standard for vitamin A is 2500-3500 I.U., not the 3500-5000 I.U. for the same-aged children in the RDA. The HANES findings contrast with the Ten State Survey, which found that in many low-income areas of the United States, households seldom served vitamin A-rich foods (Center for Disease Control, 1970). A study by Schorr et al. (1972) on the food preferences of teenagers found that none of the items described as well-liked were good sources of vitamin A.

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Some of the local surveys found evidence of dietary vitamin A deficiency among school-age children. Hampton et al. (1967) found low vitamin A intakes in California teenagers; Myers et al. (1968) found that children from low-income homes were deficient in the consumption of foods rich in vitamin A. Kirksey et al. (1978) noted that 69 percent of 12- to 14-year-old females had dietary intakes of vitamin A below 67 percent of the RDA. Frank et al. (1977, 1978) and Lee (1978) also found that vitamin A intakes fell below two-thirds of the RDA for some age- and sex-specific groups of school-age children.

Vitamin C. Vitamin C, also known as ascorbic acid, is a compound that prevents scurvy, a disease that is characterized by failure to grow properly, weakness, swollen joints, listlessness, lack of endurance, small hemorrhages under the skin, and gums that bleed easily.

Dietary sources of vitamin C are fruits and vegetables--especially citrus fruits and dark green vegetables. This vitamin is very sensitive to heat and air; thus, exposure to air or cooking will reduce the amount available for nutrition.

Average vitamin C intakes in the United States have increased considerably since 1965, and the mean intake for the school-age population is well above the RDA (USDA, SEA 1980). This increase is attributed to the increased fortification of beverages with vitamin C and to the increased availability and consumption of citrus fruits (Pao, 1979).

HANES data also showed all groups of children consumed average levels of ascorbic acid that were above the standard (Abraham et al., 1974). In contrast, the Ten State Survey found that vitamin C intake was associated with income. Deficient vitamin C intakes were found in the low-income populations. Some other earlier studies (Hampton et al., 1974) and some more recent studies (Frank et al., 1977; Kirksey et al., 1978; Lee, 1978) also documented deficient intakes of this vitamin.

B Vitamins. Each of the B vitamins is a component in all body cells. A dietary source is necessary for growth, reproduction, nerve and brain function, blood formation, and normal cell function. The B vitamins for which RDA have been established are thiamin, niacin, riboflavin, vitamin B_6, vitamin B_{12} and folic acid (folacin).

Intakes of thiamin and niacin are related to the intake of total calories. Therefore, ethnic and income groups found to have caloric intakes below standards are more likely to have individuals below standards for thiamin and niacin as well. Besides the niacin present in foods, niacin can also be manufactured in the body from tryptophan, which is one of the amino acids in protein. Therefore niacin intakes are usually adequate when protein intakes are high, as in the United States. In the NFCS all groups of school-age children including those from low-income households had average intakes of thiamin and niacin that were above 100 percent of the RDA (USDA, 1980).

According to the NFCS, intakes of riboflavin among children in the United States decreased between 1965 and 1977. Nevertheless, mean intakes of the national sample, as well as those of low-income children, were above 100 percent of the RDA. Larsen et al. (1974) found riboflavin intakes to be above the 1968 RDA for Mexican-American children in Texas. Frank et al. (1977) found that the intakes of most children in Franklinton, Louisiana met the 1974 standard. However, Lee (1978) found that riboflavin intakes were below the 1974 RDA for white females. This survey found a large difference in the riboflavin intake of white and black males (i.e., 2.4 mg vs 1.6 mg, respectively). The Ten State Survey also found that black children consume less riboflavin than whites (Center for Disease Control, 1972). These differences could be explained by differences in milk consumption. Milk consumption habits of teenagers from different ethnic backgrounds in New York

City was studied by Lopez et al. (1980). These researchers found that 69 percent of Hispanic children, 74 percent of white children and only 41 percent of black children reported consuming two or more cups of milk per day. There was a significant relationship ($p < .02$) between milk consumption and riboflavin intake; teenagers who reported consuming three or more cups of milk per day were least likely to have deficient riboflavin intakes.

Intakes of the remaining three B vitamins--B_6, B_{12} and folic acid--have not been studied as extensively as intakes of thiamin, riboflavin and niacin, since Recommended Dietary Allowances for these vitamins were first set in 1968. The NFCS is the only national survey that assessed vitamin B_6 and B_{12}. None of the national surveys assessed folic acid intakes.

The vitamin B_{12} intake of all age-sex groups of school children in the NFCS was above the RDA standard, with averages ranging from 121 to 192 percent. Vitamin B_6, however, may be a problem for some groups, since the average intakes of all age-sex groups fell below 100 percent of the RDA. The values for males were only slightly below standards, but averages among females were only 65 to 80 percent of the standards. The lowest average intake (i.e., 65 percent of the RDA) was found among 15- to 18-year-old girls. Girls in this age group living in households with less than $6,000 income per year obtained an average of only 56 percent of their RDA for vitamin B_6.

Some of the local studies indicate that folic acid nutriture may also be a problem for some teenage girls. Daniel et al. (1975) found that folate intakes of adolescents were generally inadequate compared with the 1974 RDA. There was no difference in folate intake that could be attributed to income, but differences were observed according to race. At puberty, blacks had greater intakes of folic acid than whites, but in late adolescence this finding was reversed.

Van de Mark and Wright (1972) studied the folate intakes of pregnant and non-pregnant teenage girls. They found that 13 percent of the pregnant girls and 15 percent of the non-pregnant girls had intakes that met only 67 percent of the RDA.

Minerals

Several mineral elements are essential for the proper functioning of the body. Some of them are considered to be "macro-minerals" because they are present in the body in amounts greater than .01 percent of body weight. Others are called "trace elements" because while they are necessary in the diet of humans, they are needed in very small amounts--less than 100 milligrams per day. Not all of a mineral that is ingested is utilized; only a certain percentage is absorbed. This percentage depends on a number of factors, such as how much was ingested and what other substances were eaten at the same time; some substances enhance and others hinder absorption.

Calcium. There is more calcium in the body than any other mineral. It is mainly used for teeth and bone formation. All of the calcium for skeletal growth has to be derived from the diet. Milk and other dairy products are the chief sources of calcium. Vitamin D, which is used to fortify milk, aids in the absorption of calcium.

Mean intakes of calcium have declined in recent years. The Nationwide Food Consumption Survey found that the ingestion of dairy products also declined between 1965 and 1977 (Pao, 1979). Phillips and Briggs (1975) found a 22 percent decrease in milk consumption between 1960 and 1973, and a 111 percent increase in soft drinks during the same period. Large amounts of phosphorus (phosphorus is found in soft drinks) hinder the absorption of calcium--the combination of a fall in calcium intake and an increase in phosphorous intake could have an important effect on the calcium nutriture of children.

The age and sex group most at risk for calcium deficiency appears to be females over the age of 12. Mean intakes of this group in the NFCS ranged from 64 to 74 percent of the 1980 RDA (USDA, SEA, 1980). HANES generally found more adequate levels of calcium intake, but the HANES standards for calcium are only one-half of the RDA (Abraham et al., 1974).

Deficiencies of calcium intake repeatedly show up in the small-scale surveys. Kirksey et al. (1978) found that 29 percent of girls aged 12 to 18 had intakes that were below two-thirds of the RDA. Lee (1978), also studying teenagers, found that average calcium intakes were less than two-thirds of the RDA among girls.

Racial differences are also observed for calcium intake. HANES found that in all age groups and income levels, blacks consumed less calcium than whites. According to the HANES data, mean intakes of calcium per 1000 calories were fairly comparable between blacks and whites. The HANES authors say that this indicates that food selected by white persons did not contain more calcium than that selected by blacks, but that white persons had greater total caloric intakes (Abraham et al., 1974). In other words, it was the quantity, not the quality of food that made the difference.

Iron. Iron plays an important role in the respiratory process. A deficiency of this trace element in the diet is the most common cause of anemia. A further discussion of the importance of iron is provided in Chapter II.

Of all nutrients that are commonly studied in dietary surveys of children, iron is the one most consistently found to be deficient. Adolescents are especially at risk, and females consume inadequate intakes more often than males.

In the Ten State Nutrition Survey, 80 percent of 10- to 16-year-old females had iron intakes below the standard (Center for Disease Control, 1972).

HANES data show that adolescents of both sexes, ages 12 to 17, had low iron intakes. In the group with incomes below poverty, black children ages 6 to 11 also had iron intakes that fell below standards (NCHS, 1975). In the NFCS (USDA, SEA, 1980) children 6 to 8 years old and males 9 to 11 years old had adequate iron intakes, but all other age-sex groups of school children had intakes below 100 percent of the RDA. The poorest intakes were among females aged 15 to 18, who consumed only 62 percent of the RDA for iron. In the group with family incomes less than $6,000 per year, the lowest average iron intakes were 55 percent of the RDA for 12- to 14-year-old females and 56 percent of the RDA for 15- to 18-year-old females.

Low intakes of iron among teenagers are related to the iron density of the typical American diet. The average U.S. diet contains approximately 6 mg of iron per 1000 kilocalories (Briggs & Calloway, 1979). In order for teenagers to meet their RDA for iron they would have to consume nearly 3000 calories per day. This would exceed the average calorie requirements of many teenagers, especially females. Other studies that have found low iron intakes include: Frank et al. (1977); Greger et al. (1978); Hampton et al. (1967); Lee (1978); Prothro et al. (1976); and Van de Mark and Wright (1972).

The consequences of low iron intakes in relation to the RDA are difficult to evaluate. The RDA for iron is based on an estimate that approximately 10 percent of the available iron in the diet will be absorbed (National Research Council, 1980). However, it is now known that dietary iron consists of two forms--heme and non-heme. Approximately 40 percent of the total iron in animal products, including meat, poultry and fish, is heme iron. The remaining 40 percent in animal products and all of the iron in vegetable products is non-heme iron. Research suggests that approximately 23 percent (rather than 10 percent) of heme iron present in a meal is absorbed. The absorption of non-heme iron is much less (3-5%), but absorption of non-heme iron is improved if ascorbic acid (vitamin C) is present (Monsen et al., 1978). Dietary surveys do not distinguish between heme and non-heme iron. However, the NFCS (USDA, SEA, 1980) found that school-age children obtain 30 to 35 percent of their total dietary iron from meat, poultry, and fish. Furthermore, the average intake of vitamin C is above standards for all age-sex groups. Nevertheless, these facts do not rule out the possibility that some groups of school-age children are at risk of iron deficiency.

Other minerals. In addition to calcium and iron, other minerals have important functions in human nutrition. Trace minerals such as zinc, magnesium, copper, manganese, fluoride, chromium, selenium, and molybdenum act as cofactors in a number of body reactions involved in the synthesis of tissues or the production of energy. Electrolytes such as sodium and potassium are needed for proper fluid balance. Of these various minerals, RDA have been set only for zinc and magnesium. In the opinion of the National Research Council, not enough is known about human requirements for the others to set Recommended Dietary Allowances; however, "estimated safe and adequate" ranges of intake were published in the 1980 edition of the RDA (National Research Council, 1980).

Not many dietary surveys have assessed intakes of these minerals. One reason is that food composition tables contain missing and/or inaccurate values for many items. The NFCS is the only national survey containing information for trace mineral intakes of school-age children, and only data on magnesium are reported. Intakes of all age-sex groups of school-age children fell below the 1980 RDA. The lowest intakes were found in children aged 15 to 18. On the average, males in this age group consumed 79 percent of their RDA for magnesium and females consumed 71 percent. In the same age group of children from low-income households, males consumed an average of 65 percent of the RDA and females consumed an average of 72 percent.

Some of the local studies suggest that problems may also be encountered with the other trace minerals. For example, Greger et al. (1978) found that mean intakes of zinc among elementary school children in Indiana were 60 percent of the RDA. In this study over one-third of the females consumed less than two-thirds of the RDA for zinc.

The concern about some minerals is with overconsumption, rather than deficiency. Intakes of sodium fall into this category because there is evidence that excesses of sodium are detrimental to people who are susceptible to high blood pressure (National Research Council, 1980). The Dietary Guidelines published by the U.S. Government advise against consuming "too much" sodium (USDA-DHEW, 1979).

Sodium is present naturally in most foods, but the largest source is salt added to food during processing or preparation. Actual sodium consumption is not reported in any of the national surveys, but HANES found that salty snack foods are consumed more frequently by children than by any other age group studied. Only 16 percent of children reported that they seldom or never eat these foods. In both the 6-to-11 and 12-to-17 age groups, a slightly higher percentage of males than females of both races were found to consume salty snack foods once or twice a day. A higher percentage of blacks than whites also consumed these foods. The frequency was almost twice as great among black females as among white females.

In contrast with these findings, one small study conducted by Prothro et al. (1976) found that among low-income adolescents, whites consumed higher levels of sodium than blacks of both sexes, but the difference was significant only for males. The geographical location and income level of the sample could be responsible for the difference between these results on sodium intake and the HANES data on the intake of salty foods.

Frank et al. (1978) also assessed sodium intakes among children 9 to 11 years old with results more in keeping with the HANES findings. Sodium intakes per person ranged from 2600 mg to over 11,000 mg per day. Black females ingested significantly greater amounts of sodium than any other sex-race group.

Other Dietary Habits. In addition to actual nutrient intakes compared with standards, there are other aspects of the food habits of children that may indicate general problems. These include snacking behavior and the consumption of sweets. In the Ten State Nutrition Survey, both of these behaviors were related to the incidence of dental caries among 10- to 16-year-old children (Center for Disease Control, 1972). There is also concern that frequent snacking on high-calorie foods contributes to the problem of obesity.

In HANES, consumption of desserts such as cakes, cookies, pudding, and ice cream was reported at least once daily by 44 percent of white children and 46 percent of black children between 6 and 11 years of age. The frequency of eating these foods was somewhat less among older children.

According to the NFCS, sugar and sweets (including granulated sugar, jams, jellies, syrups and candy) declined in overall consumption between 1965 and 1977, with the largest decrease reported among teenage girls. However, children and teenagers remained the largest users of candy: between 8 and 15 percent of school-age children reported eating candy on the day of the survey. More females reported eating candy than males, and the biggest users in both sexes were children 9 to 11 years old.

In contrast with sugar and sweets, the consumption of soft drinks (both carbonated and non-carbonated) increased substantially between 1965 and 1977. Teenagers 15 to 18 years of age had the highest usage: 56 to 60 percent of children in this age group reported consuming soft drinks on the day of the survey. Average quantities were 630 grams for males and 474 grams for females. It is also of interest that between 1 and 3 percent of teenagers reported consuming alcoholic beverages on the day of the survey.

Eating frequencies were also assessed in the NFCS and in some of the local surveys. Over half the sample of school-age children in the NFCS reported eating more than three times a day. Between 30 and 40 percent of the children reported eating at least one snack, and between 16 and 30 percent reported eating two snacks or more. The percent of children who reported eating no breakfast or lunch is shown in Table III-4. These data show that skipping lunch is more prevalent than skipping breakfast, that skipping both meals increases with age, and, at least among older children, more females skip meals than males.

Table III-4. Percent of School-Age Children Reporting Eating No Breakfast or Lunch

Age and Sex		Percent of Children Reporting	
		No Breakfast	No Lunch
Males and females			
ages	6-8	3.5	12.7
Males			
ages	9-11	7.5	15.0
	12-14	7.8	20.5
	15-18	13.9	23.2
Females			
ages	9-11	4.6	17.3
	12-14	14.4	18.4
	15-18	23.2	24.0

(Source: National Food Consumption Survey, Preliminary Report No. 2, USDA, SEA, 1980)

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The eating frequency behavior of children could explain some of the differences in nutrient intake discovered in the surveys. For example, Frank et al. (1978) divided the Bogalusa children into groups according to the number of times per day that they consumed food. It was found that children who had the greatest eating frequency (9 to 12 eating times per day) had an average calorie intake that was 1.8 times greater than the group with the lowest eating frequency (5 or fewer times per day). These children also had significantly greater intakes of protein, carbohydrate, sucrose, starch, saturated and polyunsaturated fat, cholesterol, sodium, iron and calcium. Frank et al. also found that the children obtained over one-third of their total daily energy, on the average, from between-meal snacks.

Discussion

Data from dietary surveys indicate that some nutrients pose problems for school-age children. (These surveys are summarized in Table III-5.) Of those nutrients most frequently studied, calcium and iron are consistently found to be below standards. Older children, especially adolescent females, are at greatest risk. The national surveys indicate that average levels of vitamin A and vitamin C are above standards for most children, but some of the local studies suggest that these nutrients may be low in the diets of some subgroups, depending on age, ethnic background and geographic location. Generally, levels of protein, thiamin, niacin and riboflavin are adequate. Other nutrients have not been studied as extensively, but there is some evidence from the National Food Consumption Survey and from local studies that vitamin B_6, magnesium, zinc, and folic acid intakes may be deficient among teenagers.

Intakes of nutrients among children are affected by income and ethnic background. All of the national surveys show that caloric intakes and intakes of most nutrients are lowest among children from low-income households. Comparison of nutrient densities reveals that these differences by income level are not due to differences in the quality of food consumed.

Rather, poor children have deficient diets because the quantity of food consumed is inadequate (Lowe et al., 1975).

Differences in intake by ethnic background have mainly been confined to comparisons between black and white children. Variable patterns are discovered, depending on the nutrients studied. It is fairly consistently found that black children consume less riboflavin and calcium than white children. This has been related to lower intakes of milk among black children (Lopez et al., 1980).

Other dietary problems among school-age children are indicated by food consumption and eating frequency patterns. Children consume a substantial portion of their total energy (approximately 33 percent) in between-meals snacks. At the same time, meal-skipping is not uncommon, especially among teenage girls. Food frequency data from HANES and the NFCS reveal that children are large consumers of desserts, candy, soft drinks and salty snacks. These patterns contribute not only to the deficient intakes shown by the surveys, but also to other problems such as obesity and dental caries.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NATIONAL SURVEYS		
HEALTH AND NUTRITION EXAMINATION SURVEY (HANES)		
Abraham et al., 1974 Comments: (1) Risk of bias because response rate failed to meet the requirement of the original probability design; (2) Estimates are based on weighted observations, data inflated to the level of the total population; (3) No statistical differences calculated between income and ethnic groups; 4) Above poverty-level blacks as few as 25 individuals per cell (p. 24); (5) Used its own standards rather than the RDA (Table 3).	20,749 persons 1-74 years old 79% white 20% black 1% other 2 income levels: above and below poverty 24-hour recall	Whites of high-income group had highest energy intakes and blacks of low-income group had the lowest. Mean intakes of calcium and vitamin C were found to be satisfactory or better for 6-17 year olds of both income and ethnic groups. Mean vitamin A intakes were unsatisfactory in 12-17-year-old blacks in the above poverty group. Mean iron intakes in 12-17 year olds was 23% to 33% below standards. Black children, 6-11 years of age, in the low-income group, had mean iron intakes 19% below standards.
NATIONWIDE FOOD CONSUMPTION SURVEY (NFES) USDA, SEA, 1980 Comments: Number of subjects in each age group not shown.	48 contiguous states 8,661 individuals in the 1977 spring survey (i.e., children and adults). Approximately 33,000 for all 4 seasons during 1977-1978. 24-hour recall plus 2-day record Conclusion from 24-hour recall only Comparison of the 1965 and 1977 survey	Energy, fat, calcium, and protein intakes of 6-18 year olds decreased, but iron and vitamin C intakes increased between 1965 and 1977. Intakes of protein, riboflavin, niacin, phosphorus, vitamin A, and vitamin B_{12} were above 1980 RDA for all groups of school-age children. Children 6-8 years old obtained over 100% of their RDA for all nutrients except for magnesium. All children ages 9-18 obtained less than 100% of the RDA for calcium, magnesium and vitamin B_6. Iron intake was below 100% of the RDA in all school age children except males 6-11 years of age.
USDA, SEA, 1979	15,000 households 7-day data collected by interview with person responsible for	Surveys amount of money spent on food both at home and away from home.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	food planning and preparation, and with aid of notes, shopping lists, etc; households had minimum 7 days' warning.	The average money value per week was highest in the Northeast, in surburban areas, and in small households. Meals eaten away from home increased from 13% in 1965 to 19% in 1977. Snacks increased only from 4 to 5%.
TEN STATE NUTRITION SURVEY		
Center for Disease Control, 1972	Children ages 12-16 years old from 10 states and New York City	Conclusion: (1) Dietary data confirmed that a substantial number of children had intakes below standards; (2) A significant proportion of the children were undernourished or at high risk of developing nutrition problems. Poor nutrition was found most often among blacks, then Spanish-Americans, and least among whites.
Lowe et al., 1975 Comments: (1) Vitamin and mineral supplements not included; (2) Claims "significant correlation" (p.32) between income and ethnicity, but provides no statistical significance.	1,027 persons 1-3 years old 270 white males 265 white females 246 black males 246 black females 3,054 persons 12-16 years old 790 white males 767 white females 681 black males 816 black females 24-hour recall	With sex, race, age held constant, intakes reflected socioeconomic status; nutrient intakes increased with income (most striking for vitamin C). With income, sex and age held constant, black children had lower median intakes of energy and most nutrients than white children. Nutritional quality of diets expressed as mean amount of nutrients/1000 kcal showed little significant correlation with income or ethnicity. There was a significant correlation between income and nutrient density only with vitamin C. Conclusion: The quantity of food, rather than the quality, appeared to be the major dietary problem; i.e., inadequate energy intakes rather than "unbalanced" diets.
LOCAL SURVEYS		
Brunswick, 1969 Comments: (1) Part of a larger study; (2) Investigated what adolescents view as their own health problem.	New York City 122 persons 12-17 years old	Found 28% of subjects not eating the right kind of food, 12% who did not eat the right amount of food, and 10% who did not eat regularly.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	48% white 32% Spanish 20% black Interviewed by structured questionnaire.	50% of white and black females claim to eat too much; 20% of black females claimed not to have enough to eat. Black females had poorer eating patterns than all other groups. 50% of black males claim to eat more in snacks than in meals.
Burroughs & Huenemann, 1970	Coachella Valley, California 101 children 6 months to 9 years old 1/3 of sample = 5-9 years old Energy intake data on 20 children, 6-9 years old 85% Mexican origin Diet history, 24-hour intake, plus shopping list	Mean iron intakes ranged from 7.3 to 11.5 mg; intakes increased with age. Protein intakes were above allowance; animal protein consisted of 65%-85% of total. 25% of the children received less than 80% of the RDA for energy. 10% of 6-9 year olds received 120% of their RDA of energy. Intakes of vitamins A, C, thiamin, riboflavin, and niacin were high. All children but 4 exceeded 90 mg/kg body weight/day for fiber, and adequate intake.
Christakis et al., 1968	New York City 619 children 10-13 years old 56% female 44% male 64% Puerto Rican 14% Chinese 10% black 8% white 4% other Low income 24-hour recall diet histories, and frequency of 6 food groups	6.6% of the subjects were judged to have excellent diets, 20.2% adequate diets, and 73.2% poor diets. Chinese had better diets than the other groups. Puerto Ricans had the poorest. Children from families that were not on welfare had twice the frequency of excellent diets compared to children whose families were on welfare. More subjects evaluated as obese had excellent diets than the others.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Based on the 1964 RDA, diets were rated as excellent if 9 nutrients exceeded 1/3 RDA, adequate if the 9 nutrients met 1/2 to 2/3 RDA, and poor if the 9 nutrients were less than 1/2 RDA.	
Daniel & Rowland, 1969 __Comments__: (1) Foods were divided into groups (collapsed into five categories) and number of servings counted; (2) Meal was defined as two or more food items; (3) Ethnic breakdown not provided; (4) Significant tests were not reported.	Birmingham, Alabama 268 children 11-18 years old 145 females 123 males Low income Black and white 24-hour recall	Majority did not eat breakfast; more boys ate breakfast and lunch than girls. More 16-18 year olds (both sexes) ate evening meals than other age groups. Most snacks were eaten at mid-afternoon. More snacks were eaten at bedtime than at midmorning. At ages 12-15, girls ate more snacks. At ages 16-18, boys ate more snacks.
Frank et al., 1978	Bogalusa, Louisiana 185 children 9-11 years old 65% white 35% black 24-hour recall	19% of the boys and 25% of the girls had energy intakes below 67% of the RDA. Energy was derived from protein (13%), carbohydrates (49%), and protein (38%). Protein and fat were derived mainly from animal sources. 33% of the subjects ingested less than 67% of the RDA for vitamins A and C, and for niacin. On the other hand, intakes over 100 percent of the RDA were noted for protein, riboflavin, and iron. White females consumed the lowest levels of energy, protein, fat, carbohydrate, cholesterol, and sodium. All females, white and black, consumed a mean of 10 grams less protein than the males. White males had the greatest energy intakes of all groups. Average cholesterol intake was 324 mg/day per person. Polyunsaturated to saturated fatty acid ratio was 0.4. No statistically significant racial or sex differences were noted for fat and cholesterol intakes.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Average mean sugar intake was 144 grams, or 68 grams/1,000 kilocalories. Sucrose intake averaged 98 grams, or 46 grams per 1,000 kilocalories. White males and black females had a statistically significantly greater starch intake than white females ($p < .01$). Sodium intake ranged from 0.26 grams/person to 11.13 grams. Black females ingested a statistically significantly greater amount of sodium than the other ethnic-sex groups ($p < .05$).
Frank et al., 1977 __Comment__: Very small sample.	Franklinton, Louisiana 68 children 51% male 49% female 72% black 28% white 69% 10-12 years old 31% 12-16 years old 0.4% 14 and over 24-hour recall	Mean energy intake was 2,000 kilocalories per person. Energy came from carbohydrate (48%), fat (39%), and protein (13%). More than half the protein came from animal sources. Fat source was mainly animal, but only 1/3 more from animal than from vegetable sources. Sugar--mostly sucrose--made up 25% of the total energy intake. Mean cholesterol intake was 345 mg/day/child. Protein and riboflavin intakes were adequate for most children. At least 33% of the males consumed less than 67% of the RDA for vitamin A, calcium, niacin, vitamin C, and iron. 45% of the females received less than 67% of the RDA for vitamin A, vitamin C, iron, calcium, thiamin, and niacin. No significant associations were found between nutrient intakes and serum lipids, blood pressure levels, or anthropometric measurements.
Greger et al., 1978 __Comment__: Sample is not random.	Northwest Indiana Females, grades 6-8	Subjects ate significantly ($p < .05$) more fat in fall than in spring; other nutrient intake remained same.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

<table>
<tr><th>AUTHOR(S)
COMMENTS</th><th>SAMPLE/
METHODOLOGY</th><th>FINDINGS/
CONCLUSIONS</th></tr>
<tr><td></td><td>183 in the fall
184 in the spring
178 of above studied both fall and spring
Diet recall and diet history</td><td>Large amounts of protein were consumed, approximately 75 gm/day.
Consumption of vitamins A and C varied greatly.
Number of females consuming less than 2/3 RDA in certain nutrients was greater in spring than fall.
Intakes of protein, vitamins A and C, and Ca were similar to HANES' results.
Mean intake of iron and zinc was 60% and 75%, respectively, of RDA.
Over 1/2 of the females consumed less than 2/3 RDA for iron.
Over 1/3 of females consumed less than 2/3 RDA for zinc.
Dietary intake of all nutrients except vitamin A were significantly ($p < .01$) correlated to energy intakes.</td></tr>
<tr><td>Hampton et al., 1967
Comment: Very small sample for conclusions by ethnicity and income.</td><td>Northern California
122 teenagers
71 females
51 males
60 white
25 black
9 Oriental
50 middle income
35 upper income
9 low income
7-day food records, 4 per subject</td><td>The percentages of subjects that consumed less than 2/3 of the 1964 RDA in the following nutrients were:
<table>
<tr><th></th><th>Males</th><th>Females</th></tr>
<tr><td>ascorbic acid</td><td>31.3</td><td>15.5</td></tr>
<tr><td>calcium</td><td>19.6</td><td>49.3</td></tr>
<tr><td>calories</td><td>17.6</td><td>15.5</td></tr>
<tr><td>thiamin</td><td>13.7</td><td>5.6</td></tr>
<tr><td>iron</td><td>11.7</td><td>57.7</td></tr>
</table>
White males had significantly higher intakes than black males of protein, calcium, vitamin A, riboflavin, ascorbic acid.
Oriental males had higher intakes than black males of protein, vitamin A, niacin, ascorbic acid.
White males had higher intakes than Oriental males of carbohydrates, calories, ascorbic acid.
Black males had a mean intake of ascorbic acid that was below 2/3 RDA.</td></tr>
</table>

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		White females had higher intakes than black females of protein, calcium, riboflavin, ascorbic acid. There were no differences in intakes between white and Oriental females. Black females had a mean intake of calcium below 2/3 RDA. All females had a mean intake of iron below 2/3 RDA. Males from lower SES had mean intakes of calories and calcium below 2/3 RDA. Females from lower and middle SES had mean intakes of calcium below 2/3 RDA.
Hard et al., 1958 Comment: No information provided on how the sample was drawn, or on socioeconomic status.	Washington State Snohomish and Yakima Counties 124 females 124 males 15-16 years old 7-day food record Results compared with the 1963 RDA, which for vitamin C were: Boys 13-15, 90 mg Boys 16-20, 100 mg Girls 13-20, 80 mg	32% of the females had an intake of vitamin C of less than 50 mg/day. 34% of the males had vitamin C intakes of less than 60 mg/day. Females in Snohomish County consumed 99% of the RDA for vitamin C, males 87%. Yakima County females received 74% of the RDA for vitamin C, males 88%. Mean daily intakes of vitamin C were 62 mg for the females and 82 mg for the males.
Hodges & Krehl, 1965 Comment: An extensive study of a large sample, but data on all aspects are available on only a small number. While the total sample is stratified and random, no information is offered as to how the "real" sample compares to the total sample.	Iowa 252 teenagers 128 males 124 females Grades 9-12 Diet histories on "nutrition forms"	Mean fat intake was 145 grams, or 43.5 of the energy intake; females consumed 118 grams, or 48% of energy intake, and males 171 grams, or 49%. Mean energy consumption was 2,450 kilocalories/day for females and 3,500 for males. Mean protein consumption was 108 grams per day, 97 grams for females and 129 for males. Protein provided 11.6% of the mean energy consumption.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Protein intake is associated with height ($p < .05$) and with fatfold thickness of the scapula ($p < .05$). Fat intake was associated with increased body weight ($p < .05$) and increased serum triglycerides ($p < .05$). A number of girls and boys skip breakfast, girls more often than boys; associated with lack of time or with family habits. If lunch was consumed in the school it was usually the balanced meal of the day. If students left the school building, lunch most often consisted of french fries, a carbonated drink, and candy--sometimes with a hamburger. Snacking was common after school, while studying, and at bedtime. Foods included milk, ice cream, and cheese.
Kirksey et al., 1978 Comments: (1) Vitamin and mineral supplements included in the analysis; (2) Some cells in the analysis are as small as 5 subjects; (3) Subjects are volunteers; (4) No socioeconomic status given.	Northwest Indiana 127 females 61 in the spring 66 in the fall 12-18 years old 24-hour recall	Intakes of the following nutrients were below 67% of the RDA: Energy for 28% of subjects; calcium for 29%; iron for 65%; vitamin A for 69%; ascorbic acid for 29%; vitamin B_6 for 46%. Mean intake of vitamin B_6 was 1.24 mg/day/person, or 79% of the RDA. Conclusion: No significant seasonal effect found on intakes.
Larson et al., 1974 Comment: A form of food frequency was used that is referred to as "reliable 24-hour dietary histories" (p.29). Method of analyzing data to obtain nutrient values is not described.	Lower Rio Grande Valley, Texas 298 Mexican-American Children up to 9 years of age 83 6-8 year olds "24-hour dietary history"	Mean protein, riboflavin, ascorbic acid, and thiamin intakes exceeded the 1968 RDA for all age groups; intakes were below the RDA for energy, calcium, and vitamin D were no more than 67% of the RDA. Conclusion: Complex nutritional problems exist in this population, of which vitamin A deficiency is the most prevalent.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
Laskarzewski et al., 1980	Cincinnati 6-19 years old 294 families 230 white 60 black 158 females 136 males 24-hour recall, including Sundays	Results from simple correlations between all parents and all children were the following: saturated fat $p < .01$ polyunsaturated fat $p < .01$ total carbohydrate $p < .0001$ calories $p < .0001$ cholesterol not significant Results from analysis of covariance showed the following: cholesterol—between all parents and all children ($p < .001$); polyunsaturated fat--between all mothers and all children ($p < .001$). Interestingly, proportion of variation of children's nutrient intake accounted for by parental nutrient intake varied from 23% for cholesterol intake between all parents and all children, to 97% for carbohydrate intake between children and black fathers over 40 years of age. Black parent-child nutrient intakes had higher multiple correlation than whites for carbohydrate, saturated fat, and energy.
Lauer et al., 1975 Comments: (1) No information on the method of dietary data collection; (2) No information about the subsample with dietary data (total sample = 4,829, approximately 96% white).	962 school children 6-18 years old	79% had no fat intake or under 15 gm for breakfast. No difference by sex. Breakfast fat intake significantly correlated with serum triglyceride levels ($p < .001$), but not with cholesterol levels.
Lee, 1978 Comments: (1) Random sample, though not representative of the population by age and sex; (2) Income data only from those willing to disclose it; (3) Vitamin supplements not included in analysis.	Central Kentucky 118 teenagers 12-19 years old 72 females 46 males 85 whites 33 blacks	Mean intake of total fat, saturated fat, and cholesterol by males was significantly higher than by females ($p < .01$). Energy derived from fat was as follows: white males: 42% white females: 40% black males: 46% black females: 38% Mean intakes of cholesterol were the following (in mg):

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Mean family income: $12,445 for whites $ 7,824 for blacks 24-hour recall	white males: 475 white females: 370 black males: 442 black females: 263 Mean vitamin A intakes were (in I.U.): white males: 5,280 white females: 2,425 black males: 1,821 black females: 4,560 Mean riboflavin intakes were (in mg): white males: 2.5 white females: 1.4 black males: 1.6 black females: 1.7 Mean iron intakes were (in mg): white males: 13 white females: 9 black males: 11 black females: 9 White males had a higher intake of energy and other nutrients, except ascorbic acid, than other groups. Females had lower intakes of nutrients other than ascorbic acid than males. The most deficient nutrient intakes (less than 2/3 RDA) were vitamin A for males and calcium and iron for females. Black females had a significantly greater number of snacks than other groups ($p < .01$). 26% indicated the use of vitamin supplements. Conclusions: (1) Wide range of intakes were observed in the sample; (2) High incidence of diet-related problems appears to be evident, e.g., low intakes of calcium, vitamins A and C, and irregular eating habits.
Lopes et al., 1980 Comment: Sample is so small that some cells have less than 5 individuals.	New York City 141 adolescents 13-19 years old	Milk consumption habits by ethnicity were the following: 69% of Hispanic, 74% of the whites, and 41% of the blacks consumed 2 or more glasses of milk/day.

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	84 Hispanics 32 black 23 white 2 other Diet history	Conclusion: There appears to be a significant relationship ($p < .02$) between milk consumption and riboflavin nutriture; teenagers who reported to consume 3 or more cups of milk per day were least likely to have riboflavin deficiency.
Myers et al., 1968	Boston 332 children 9-13 years old Equal number males and females 228 black 94 white 10 unknown 4-day diet records The composition of meals was evaluated and rated as satisfactory or unsatisfactory.	Lunch was the poorest of the 3 meals (the schools had no lunch program). Many of the children were eating poorly. There was low consumption of milk, meat, eggs, cheese, citrus fruit, green and yellow vegetables, margarine and butter. Older children had poorer evaluations for meals than younger children. Black children scored lower in every evaluation than whites, with a sharper deterioration with age. Males had poorer ratings for meals than females. Females showed a more pronounced decline in eating habits with age.
O'Neal et al., 1976 Comment: Both whites and blacks were included in this study; however, data provided for whites only, though conclusions are drawn by ethnicity.	Missouri, statewide 130 white children 6-16 years old Broad income group Diet history questionnaire	Following the 1974 RDA, results show that the following proportions of the sample consumed less than 2/3 RDA for iron: over 35% of females over 10; over 15% of males 10-16; over 5% of children 6-9. In the 10-16-year-old group, approximately 30% of the females had iron intakes below 50% of the RDA, but less than 10% of the males in this age group had such low intakes.
Prothro et al., 1976 Comment: Very small sample, only 8 non-black individuals in this age range (part of a larger study of 102 individuals).	Macon County, Alabama 27 adolescents 13-18 years old	Dietary intakes were low in calcium, iron, and energy. Non-blacks had higher intakes than blacks of the following nutrients: energy (32%), protein (64%), carbo-

Table III-5. Surveys that Include Dietary Methods as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	19 black 8 non-black Low income 3 24-hour recalls per participant	hydrate (82%), fiber (100%), fat (44%), sodium (108%), and calcium (101%). Ethnically, the differences were not statistically significant for females but were for males. For the following nutrients, non-black males had higher intakes of the following: protein ($p < .05$) carbohydrate ($p < .05$) sodium ($p < .05$) calcium ($p < .02$) phosphorus ($p < .05$) vitamin D ($p < .01$) Blacks had higher intakes of the following nutrients, but differences were not statistically significant: vitamin A--9% folic acid--100%.
Van de Mark & Wright, 1972 Comments: No ethnic or socio-economic status information provided.	Birmingham, Alabama 114 pregnant females 12-17 years old 40 non-pregnant females 12-15 years old From the University of Alabama Medical Center 3-day food intake records	The iron intake of the pregnant females was more than 6 gm lower than the 1968 RDA. The mean intake of iron by the pregnant females was 10-15% higher than non-pregnant females. Only 13% of the pregnant and 15% of the non-pregnant teenagers met 67% of the RDA for folic acid; however, the intakes of folic acid of the pregnant females were higher than those of the non-pregnant females. Conclusion: The intakes of teenage females of certain nutrients, such as iron and folic acid, are below acceptable standards. Thus, pregnant teenagers may not be able to meet their increased needs.

B. *What Nutrition-Related Conditions Have Been Identified With The Aid of Biochemical Techniques To Be Potential Problems For School-Age Children?*

Biochemical measurements on tissues (e.g., liver, hair, nails, red blood cells) and body fluids (e.g., plasma, serum, urine) can be of considerable value for assessing the nutritional status of an individual or a population. They frequently provide information about nutritional deficiencies before such deficiencies are manifest clinically. Studies of school-age children using biochemical measures of nutritional status are summarized in Table III-6. The methods of obtaining biochemical measurements and standards used for interpretation are discussed in Chapter II.

Protein

Most studies indicate that protein levels are adequate in the school-age population. The Ten State Survey found that there were essentially no children with unacceptable concentrations of total serum protein or serum albumin.

In HANES, there were no deficient or low serum albumin levels among 6- to 17-year-old children, above or below poverty. Low values of total serum protein were also virtually non-existent among blacks. However, white children did show some evidence of low total serum protein. The highest prevalence (approximately 4.7 percent) was shown in 6 to 11 year olds in the above-poverty group. The HANES authors speculate that the differences in total serum protein are due to higher levels of gamma globulins in low-income children and blacks (Abraham et al., 1974). Gamma globulin levels are not good indicators of nutritional status. The levels in blood serum normally increase as part of the body's resistance to infectious disease.

A small study of 50 low-income black children reported by Bell (1971) found that over 38 percent of the children had low total serum protein values. The average albumin/globulin ratio was 1.46, which is much lower than ratios reported for white children and for black children of higher socioeconimic status. This finding conforms with the HANES data.

Vitamin A

Vitamin A nutriture is usually assessed by measuring plasma or serum levels of either vitamin A or carotene. There is some controversy among researchers who have investigated vitamin A nutriture through biochemical means about the extent and severity of deficiency of the vitamin among the school-age population in the U.S. Although vitamin A deficiency does not appear to be widespread, it has been discovered in subgroups of the low-income population.

In the Ten State Nutrition Survey, from 30 to 50 percent of Spanish-American children under 17 years of age had low or deficient values for vitamin A (Center for Disease Control, 1972). These children came primarily from the state of Texas. Similar results have been obtained from some of the local studies. For example, Larson et al. (1974) found low vitamin A levels in 33 to 50 percent of Mexican-American children in the lower Rio Grande Valley in Texas. These authors also claim to have discovered clinical signs that could be related to vitamin A deficiency in a large proportion of the children. There is little available evidence of vitamin A deficiency among Hispanic children in other states.

Other ethnic groups appear to have fewer vitamin A problems. In the Ten State Survey, low vitamin A values were seen in only 1.5 percent and 10 percent of white and black children, respectively. Two of the smaller studies (Lee, 1978; Prothro et al., 1976) also found that black children had a higher prevalence of low serum vitamin A values than whites. Bell (1971), studying only black children, found that 18 percent had very low serum vitamin A values and that 6 percent were classified as deficient.

The prevalence of low serum vitamin A values found in HANES was generally lower than that found in the Ten State Nutrition Survey and the local surveys. Low values were found for fewer than 4 percent of 6- to 11-year-old white children and fewer than 2 percent of 6- to 11-year-old black children in the below-poverty group. In the above-poverty group, fewer than 1 percent of black or white children aged 6 to 11 had low serum vitamin A values. In the 12-to-17 age group, none of the subgroups by race or income had a prevalence of low vitamin A values greater than 0.3 percent.

The HANES data show a progressive increase in vitamin A values with age in all sex, race and income groups. However, the standards currently in use for children are not differentiated by age. It is possible that the use of standards that are inappropriate for older children underestimates the prevalence of vitamin A deficiency (Sauberlich et al., 1974).

Vitamin C

Vitamin C is usually measured in surveys by serum concentrations. Vitamin C data from HANES have not been released and only the Ten State Survey and a few smaller scale studies have information about vitamin C status.

The Ten State Survey data showed a positive relation between serum vitamin C levels and dietary intake. The investigation concluded that the data "do not show cause for serious concern with vitamin C nutriture of the populations surveyed. In all subgroups of the population there was generally a low prevalence of deficient and low vitamin C values" (Center for Disease Control, 1972).

Among teenagers in Central Kentucky, Lee (1978) found that more black children had low values for vitamin C than whites. Reisinger et al. (1972), studying Navaho children in Arizona, found that serum vitamin C levels of 6- to 16-year-old children were at or above acceptable levels.

Iron

Iron nutriture is usually assessed by measuring blood hemoglobin concentration or hematocrit (packed cell volume). Anemia, i.e., unacceptably low values for blood hemoglobin and hematocrit, is caused by iron deficiency. However, anemia may also be caused by factors other than iron deficiency, e.g., deficiencies of folacin and vitamin B_{12}. Therefore, measurements of hemoglobin and hematocrit must be supplemented with more specific tests before anemia can be attributed to iron deficiency. These tests include serum iron levels, percent saturation of transferrin, and plasma or serum ferritin. These tests are described in Chapter II.

Hemoglobin or hematocrit have most often been used to evaluate iron status in the nutrition surveys, summarized in Table III-6. Low values for hemoglobin in school-age children have been described in various studies as ranging from less than 2 percent to over 40 percent, depending on the age, sex, ethnic background and income levels of the groups studied.

The Nutrition Surveillance Program (Nichaman & Lane, 1979) found that 15 to 20 percent of the 6- to 18-year-old population had hemoglobin levels below standards and that 30 percent of the same age group had hematocrit levels below standards. The prevalence of low hemoglobin levels among teenage females was somewhat higher than the prevalence among teenage males (i.e., 18 percent vs 15 percent).

The Ten State Nutrition Survey and HANES found that hemoglobin values of black persons at all ages averaged 0.5 to 1.0 g/dl lower than those of white individuals, even when the subjects' incomes were matched (Garn, 1976). This affects estimates of the prevalence of iron deficiency found according to race. For example in HANES only 1 percent of 6- to 11-year-old white children in the below-poverty group had low hemoglobin values, while 7.1 percent of black children in the same age and income group had low hemoglobins. In the income group above poverty, at ages 6 to 11, the prevalence of low hemoglobin was 1.6 and 7.6 percent for whites and blacks, respectively. In the 12-tc-17 age group, 3.7 percent of lower income white children had low hemoglobin values, while 20.4 percent of lower income black children had low values. Corresponding percentages for white and black children above poverty were 2.5 and 15 percent (Abraham et al., 1974).

The same difference in hemoglobin levels between white and black children has been discovered in many of the local surveys (e.g., Daniel & Rowland, 1969; Frerichs et al., 1977; Dallman et al., 1978; Lee, 1978.)

In the study of over 4,000 children in Bogalusa, Louisiana, the mean difference in hemoglobin between blacks and whites was .64 g/dl (Frerichs et al., 1977). Dallman et al. (1979) studied data from multiphasic exams given to 1,718 white, 741 black, and 315 Oriental children in California. All were healthy and non-indigent. The median hemoglobin for blacks was .5 g/dl lower than the medians for white and Oriental children. This difference persisted when all children with abnormal hemoglobins and hematocrits (5 percent or more below the normal mean for age) were excluded from the results. These findings make it difficult to evaluate the prevalence of iron deficiency anemia in black children on the basis of hemoglobin values. Dallman et al. (1979) estimate that when the typical difference in mean hemoglobin levels between black and white children is taken into account, the prevalence of iron deficiency anemia is similar in the two groups, and that most studies consequently overestimate the prevalence of iron deficiency in black children by as much as 10 percent.

Tests of serum iron or transferrin saturation have been recommended as a way of supplementing the information obtained from hemoglobins and hematocrits (Fomon, 1977; Christakis, 1973). A serum iron below 50 g/dl and transferrin saturation less than 16 percent are used as criteria to indicate iron deficiency in children 6 to 12 years of age (Christakis, 1973). Recently the measurement of serum ferritin has gained prominence as the preferred technique for determining iron stores; however, values for school-age children were not obtained in any of the national surveys.

No school-age group in HANES had a prevalence of low serum iron values greater than 5 percent. HANES did find "evidence of iron deficiency with anemia for children and adolescents based on a relatively high percentage of low transferrin saturations" (Abraham et al., 1974). The prevalence for children aged 6 to 11 ranged from 8.9 percent (low-income blacks) to 17.7 percent (low-income whites). In children aged 12 to 17 years, the prevalence of low transferrin saturations was 6 percent (high-income whites) to 12.5 percent (low-income blacks).

The small-scale studies have produced variable findings for serum iron and transferrin saturation, depending on the geographic location and ethnic background of the subjects. Estimates of the prevalence of unacceptable values are generally higher than those found in the national surveys. For example, in Arizona, low values of serum iron among Navajo children ranged from 9 percent for 13- to 16-year-old males to 23 percent for 6- to 12-year-old females (Reisinger et al., 1972). In the same study, unacceptable values for transferrin saturation ranged from 22 percent for 13- to 16-year-old males to 50 percent for 6- to 12-year-old males; females had unacceptable values ranging from 30 percent in 6 to 12 year olds to 36 percent in 13 to 16 year olds. Burroughs and Huenemann (1970) report that 88 percent of Mexican-American children in California had serum iron levels that fell below standards. O'Neal et al. (1976) studied white children in Missouri and found low serum iron values in 25 percent of females 6 to 9 years old and 17.5 percent of children of both sexes 10 to 16 years old.

B vitamins

Measurements of urinary thiamin and riboflavin were performed in the Ten State Survey and HANES. The tests are based on a correlation between deficiencies of these nutrients and decreased excretion in the urine. HANES data for these nutrients have not been released, but the Ten State Survey did not find a high prevalence of low and deficient values for thiamin in children aged 6 to 9 years--the ranges were from 4.1 percent to 9.1 percent. Percentages of children with low or deficient values in the 10-to-16 age group were higher, from 9.7 percent to 17.6 percent. The prevalence of deficient and low urinary thiamin appears to be unrelated to ethnic background or economic status (Center for Disease Control, 1972). These findings are not easy to interpret because of the lack of information on normal urinary excretion levels for thiamin in children (Sauberlich, 1974).

According to the Ten State results, riboflavin deficiency could pose a potential problem for 10 to 16 year olds, particularly young persons in low-income-ratio states (Center for Disease Control, 1972). The prevalence of low and deficient urinary riboflavin values for children in the low-income states was 32.7 percent. Other, local studies have also raised concern about riboflavin status among low-income children. For example, a study by Lopez et al. (1975) of 100 low-income children in New York City found that 10 percent of the children showed low biochemical values for riboflavin. More recently, Lopez et al. (1980) studied riboflavin status in an ethnically mixed sample of children aged 13 to 19. This time the investigators measured riboflavin using the activity of glutathione reductase in red blood cells (see Chapter II). Overall, 23 percent of the sample of 210 children showed evidence of riboflavin deficiency. The breakdown by ethnic background showed that 34.5 percent of blacks, 19.8 percent of Hispanics and 15.4 percent of whites had deficient riboflavin levels.

Biochemical evidence of problems with other B vitamins is limited to a few small-scale studies. Some studies have shown that teenage girls are in poor folate status. Van de Mark and Wright (1972) measured whole blood folic acid in 114 pregnant and 40 non-pregnant girls aged 12 to 17. Average blood levels of folic acid fell below standards. The authors conclude that their findings indicate that dietary intakes of folic acid are inadequate among adolescent females. Other studies have shown that blood levels of folic acid among teenagers are generally adequate (Daniel et al., 1975; Prothro et al., 1976).

Kirksey et al. (1978) conducted a study of vitamin B_6 levels in 127 teenage girls aged 12 to 14. Approximately 31 percent were found to have adequate vitamin B_6 levels, as measured by a test of an enzyme (erythrocyte alanine aminotransferase) which is dependent upon vitamin B_6 for its functional activity.

The only study known to have assessed the status of vitamin B_{12} in school-age children (Prothro et al., 1976) found that levels were adequate on average, but were significantly higher in females than in males and in blacks than in whites.

The sample sizes in all of these studies were fairly small and not necessarily representative of their respective populations. More research is needed to evaluate the status of folic acid, vitamin B_6 and vitamin B_{12} among school-age children.

Trace Minerals

Although there is some concern that low levels of zinc and other trace minerals may be common, no large-scale studies of school-age children have examined these nutrients. Greger et al. (1978) examined zinc and copper status of sixth-to-eighth-grade girls in Indiana using both hair and red blood cell analyses. They found that, although dietary intakes for zinc averaged between 60 and 75 percent of the RDA, only 2 percent of the girls had low zinc values. The prevalence of low blood values of copper was 3 percent. Further research must be done to determine whether trace mineral deficiencies constitute a child nutrition problem in the United States.

Cholesterol

Elevated levels of serum cholesterol are a risk factor for cardiovascular disease among adults (Kannel et al., 1971; Chapman & Massey, 1964). Although the relationship between diet and serum cholesterol levels is far from clear, there is a general consensus that at least part of the prevalence of high serum cholesterol values in a population has a nutritional origin. Because cardiovascular disease may actually begin in childhood, some authorities recommend that measurement of serum cholesterol should be a routine part of child health screening (Fomon, 1977).

Serum cholesterol values for children 4 to 17 years of age have been reported in data from HANES (NCHS, Series 11, No. 217, 1980). Children aged 6 to 11 years had higher average serum cholesterol levels than children aged 12 to 17 years. As family income increased from less than $4,000 to $15,000 or more per year, the mean cholesterol levels of children 4 to 17 were stable within a narrow range of 166.9-168.4 mg/dl. At each income level girls had higher mean cholesterol levels than boys, except in the range from $4,000 to $6,900 per year, where the average levels of boys and girls were nearly the same.

Differences in serum cholesterol levels were observed by race. Black females aged 4 to 17 generally had the highest mean serum cholesterol levels, followed by black males. White males had the lowest mean serum cholesterol levels. Among black and white females, those from families with incomes of $10,000 or more had the highest mean serum cholesterol levels.

Serum cholesterol levels were also measured in several of the local studies (Williams et al., 1979; Frerichs et al., 1977; Christakis et al., 1968; Foster et al., 1967; Hodges & Krehl, 1965; Lee, 1978; Myers et al., 1968). In one early study by Hodges and Krehl (1965), 15 percent of teenagers in Iowa had serum cholesterol values over 200 mg/dl. Christakis et al. (1968) found that 25 percent of white children 10 to 13 years old in New York City had high (i.e., over 200 mg/dl) serum cholesterol levels.

Meyers et al. (1968) studied 297 children in Boston and found that the average cholesterol values were lower than averages reported in other studies--only 9 percent of the sample had values above 200 mg/dl.

In Muscatine, Iowa, the average serum cholesterol value of mainly white children 6 to 18 years of age was 182 mg/dl. No variation was seen by age or sex (Lauer et al., 1975). In Kentucky, Lee (1978) found that black children had higher cholesterol levels than whites. Frerichs et al. (1977) also found higher serum cholesterol levels among blacks. Mean values were 162 mg/dl for white children and 170 mg/dl for black children in the Bogalusa sample. No consistent differences were found for males and females.

Some investigators have attempted to relate serum cholesterol levels in children with other health and nutritional factors. For example, Lee (1978) found that serum cholesterol levels correlated inversely with the amount of physical activity reported by the children. A positive association between fatfold thickness and serum cholesterol levels was found by Hodges and Krehl (1965), but serum cholesterol remained negatively associated with total body weight. Foster et al. (1977) found a positive relationship between ponderosity (weight/height) and serum cholesterol levels.

None of the studies have found consistent associations between cholesterol levels and dietary intake. Hodges and Krehl (1965) found a positive relationship between sugar intakes and serum triglyceride (i.e., fat) levels, but no relationship between diet and serum cholesterol. Frank et al. (1978) found that children with the highest serum cholesterol levels had higher fat intakes but lower total carbohydrate and sugar intakes than children with the lowest serum cholesterol levels.

Serum cholesterol levels appear to be relatively stable during childhood. In a follow-up study, Clark et al. (1978) found that 50 percent of the children initially in the highest quintile for serum cholesterol levels remained in the highest quintile six years later. The long-term effects of high serum cholesterol and other blood lipids during childhood need to be studied. Further aspects of this problem are discussed in the section of this chapter that summarizes clinical signs of nutritional problems.

Discussion

Table III-6, which follows, summarizes surveys that have used biochemical methods to identify problems of school-age children. In general, biochemical deficiencies of nutrients appear to be less common among school-age children than deficiencies in dietary intake; however, problems are seen in certain subgroups.

Iron deficiency is the most frequently reported problem. The exact prevalence of this condition is difficult to establish. HANES data for white children show that the prevalence of low hemoglobin values is between 1 percent (6 to 11 year olds below poverty) and 3.7 percent (12 to 17 year olds below poverty). The figures for non-whites are less certain because hemoglobin standards currently in use may not be appropriate, at least for black children. Surveys generally show the prevalence of low hemoglobin to be several times greater in blacks than in whites, but the figures may be overestimated. Some investigators believe that if race-specific standards were used, the prevalence of low hemoglobin levels among black children would be comparable to the prevalence among whites (Dallman et al., 1979). Other indicators of iron deficiency suggest that school-age children have reduced iron stores. Serum ferritin, which is generally recognized as the best measure of iron stores, was not reported in HANES, but HANES data show unacceptable values of transferrin saturation in roughly 8 to 18 percent of the school-age population. The other surveys reviewed in this chapter suggest that some subgroups of school-age children experience higher rates of anemia and greater reductions in iron stores than the national data from

HANES would indicate. For example, anemia rates from the Nutrition Surveillance Program at the Center for Disease Control range from 15 to 30 percent (Nichaman & Lane, 1979).

Deficiencies of other nutrients are not reported as consistently in the literature as deficiencies of iron. For example, low serum values of vitamin A have been reported among low-income Mexican-American children (Ten State Nutrition Survey, Larson et al., 1977), but other studies, including HANES, have failed to show high rates of deficiency. Riboflavin may also be a problem for some segments of the low-income population. A large proportion of 6- to 10-year-old children in the Ten State Survey (i.e., 32.7 percent) had low or deficient values of riboflavin, as did two groups of low-income children in New York (Lopez et al., 1975, 1980).

Other nutrients have not been studied extensively in children. Limited evidence suggests that folic acid, vitamin B_6, and trace minerals such as copper and zinc should receive attention in future investigations.

Some studies show that school-age children may be at risk of developing high serum cholesterol levels. Mean values are reportedly within normal limits, but several local studies found relatively large numbers of children with values over 200 mg/dl (Hodges & Krehl, 1965; Christakis et al., 1968). High values, once established, appear to persist for many children. There is a need for continued research on the factors associated with serum cholesterol levels in children and relationships between childhood levels and adult risk for cardiovascular disease.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NATIONAL SURVEYS		
HEALTH AND NUTRITION EXAMINATION SURVEY (HANES)		
Abraham et al., 1974 Comment: 12-17-year-old group not cross classified by sex "because of sample size consideration" (p. 11).	20,749 persons 1-74 years old 79% white 20% black 1% other 2 income levels: above and below poverty	Hemoglobin: Ages 6-11, less than 10% of blacks of both income groups showed unacceptable values; however, ages 12-17, over 20% of below-poverty-level, and approximately 15% of above-poverty-level, showed unacceptable values. Hematocrit: Almost 30% of below-poverty-level and 20% of above-poverty-level had unacceptable values. Serum iron: Generally, blacks had a slightly higher percent of low values in the 6-17 age group than whites did. Transferrin saturation: In the 6-11 age group, whites had a higher proportion of low values than blacks at both income levels; however, in the 12-17 age group the reverse was the case at both income levels. Serum protein: For all of the 6-17 age group, whites had a higher proportion of low values at both income levels than blacks. Serum albumin: Values for all school-age children were at or above acceptable standards. Vitamin A: Values for all school-age children were at or above acceptable standards.
Johnson & Abraham, 1979	20,749 persons 1-74 years old 79% white 20% black 1% other 2 income levels: above and below poverty	Males 6 to 11 had a mean hemoglobin value of 13.2 g/dl. This value increased to 14.6 g/dl in 12-17 year olds. White males had values that were approximately 1.0 g/dl higher than blacks. Females 6-17 had a mean hemoglobin value of 13.6 g/dl. The values for white females were 0.6 g/dl higher than for blacks.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NUTRITION SURVEILLANCE SYSTEM		
Nichaman & Lane, 1979 Comments: The sample consists of persons attending public health clinics in the participating states. Data are as reported by the clinics; analysis of blood samples is not performed by CDC.	1,258 males 1,264 females 6-17 years old	The following percent of males had low hemoglobin levels: 19.2% of 6-9 year olds 18.7% of 10-12 year olds 15.0% of 13-17 year olds The following percent of females had low hemoglobin levels: 19.1% of 6-9 year olds 16% of 10-12 year olds 18.4% of 13-17 year olds The following percent of males had low hematocrit levels: 31.2% of 6-9 year olds 21.3% of 10-12 year olds 13.8% of 13-17 year olds The following percent of females had low hematocrit levels: 28.4% of 6-9 year olds 19.4% of 10-12 year olds 14.0% of 13-17 year olds
TEN STATE NUTRITION SURVEY (TSNS)	Low-income-ratio states:	
Center for Disease Control, 1972	1,168 white males 1,572 white females 2,987 black males 4,850 black females 815 Spanish-American males 1,159 Spanish-American females High-income-ratio states: 4,847 white males 6,125 white females 920 black males 1,529 black females 1,095 Spanish-American males 1,636 Spanish-American females	Conclusion: Adolescents between 10-16 years of age had the highest prevalence of unsatisfactory values. Males exhibited more evidence of malnutrition than females.
Martin & Beal, 1978	40,847 persons Low-income-ratio states Kentucky, Louisiana, South Carolina, Texas and West Virginia. High-income-ratio states: California, Massachusetts, Michigan, New York, and Washington. The standard for males over 12 years old was 1.5 g/dl higher than for females.	Spanish-American children from low-income states showed low plasma vitamin A levels. (There was no supporting clinical evidence of deficiency.) Low blood levels for hemoglobin and hematocrit were found in all segments of sample. For blacks, values related to iron nutriture were lower than for whites.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Adolescent males showed a high frequency of low hemoglobin levels.
LOCAL SURVEYS		
Bell, 1971 Comment: Standards not defined by age and sex groups.	North Nashville, Tennessee 50 black children Average age 9.6 years (includes infants) 58% males 42% females Low income Criteria for low and deficient levels were from the Interdepartmental Committee on Nutrition for National Defense (1963).	The average hematocrit was 38.8%; 10% had values less than 34%. 18% of the subjects had very low serum vitamin A levels; 6% were classified as deficient. 6% had low serum ascorbic acid levels. Over 38% had low total serum protein levels; 22% of these were deficient. The average albumin/globulin ratio was 1.46, considerably lower than values reported for white and black children of higher SES. Conclusion: 64 percent of the population examined exhibited low or deficient levels of nutrition.
Burroughs & Neunemann, 1970 Comments: (1) Standards not defined; (2) Cannot separate school-age from other children, thus findings apply to the entire population.	Coachella Valley, California 168 children 6 months to 9 years old 85% Mexican origin	52% of the sample had hemoglobin values below standards, 88% had serum iron levels below standards and iron-binding capacity above standards.
Christakis et al., 1968 Comment: Sample is small for analysis by ethnicity.	New York City 642 children 10-13 years old 56% females 44% male 64% Puerto Rican 14% Chinese 10% black 8% white 4% other Low income A hemoglobin level of 10 g/dl or less was considered to be deficient.	3% of the sample showed deficient hemoglobin levels. 4.6% of the males and 7.6% of the females had hematocrit values of under 35%. Blacks had the lowest mean hematocrit values, and whites had the highest mean values. Females exhibited significantly lower amino acid ratios than males ($p < .01$). 38% of the Chinese had Mean Corpuscular Volume (MCV) of 95 and over, while only 18% of the other students did.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		25% of white subjects had cholesterol levels of 174 mg and higher.
Clark et al., 1978 Comment: Triglycerides done only 2 and 4 years follow-up.	Muscatine, Iowa 8,909 school children 5-18 years old 816 repeated after 6 years 50% male 50% female	For cholesterol, 6-year follow-up correlation was 0.61; however, 57% of the children originally in the lowest quintile were there after 6 years, and 50% of those initially in the highest quintile also remained there.
Dallman et al., 1978	San Francisco 2,774 children 5-14 years old 1,718 white 741 black 315 Oriental	Median hemoglobin values were consistently lower among black children than among whites or Orientals of the same sex and age. These differences persisted when abnormal values were excluded. The difference was largest in males aged 10-14 and least in children aged 6-9. Median hemoglobin values for black children were 0.5 g/dl lower than values for whites or Orientals. Values of Orientals and whites were almost identical.
Daniel et al., 1975	Birmingham, Alabama 451 adolescents 12-17 years old 2 income levels: low and middle-upper Low income sample: 130 black males 116 black females 67 white males 50 white females Middle-upper income sample: 88 white females	Plasma folate concentration decreased as the maturity ratings of the subjects increased for both sexes ($p < .0001$). There appeared to be no relationship between folate levels and age. Females had higher plasma folate values than males and the middle-upper-income ($p < .05$) females' values were higher than low-income females ($p < .0001$). Conclusions: (1) Maturity appeared to be a significant factor as opposed to age; (2) Plasma folate

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		levels were higher in girls than in boys; however, dietary folate intake was vice versa; (3) family income did not appear to be a significant factor.
Daniel & Rowland, 1969 Comments: (1) Comparisons made with other groups without data or documentation; (2) Most studies use 12 g/dl as the hemoglobin criterion for iron deficiency in adolescent boys.	Birmingham, Alabama 268 black and white children 11-18 years old 145 females 123 males Low income 11 g/dl as hemoglobin "norm" for both boys and girls	Hemoglobin levels were acceptable, after excluding 4 boys and 6 girls.
Foster et al., 1977	Bogalusa, Louisiana 3,524 children 5-14 years old 37% black 63% white	White males and to a lesser extent white females showed a positive correlation between ponderosity (W/H^3) and serum cholesterol and triglyceride values. Black children showed this correlation only with triglyceride levels.
Frank et al., 1978	Bogalusa, Louisiana 10 year olds	The mean hemoglobin of the sample was 12.9%. 9.7% of the blacks and 3.5% of the whites were ranked as having low hemoglobin according to TSMS standards. There appeared to be no significant relationship between dietary iron intake and hemoglobin levels. Total serum cholesterol averaged 164 mg% for males and 68 mg% for females. Children with middle and high serum cholesterol values showed significantly greater fat intakes than those with the lowest cholesterol levels. A reverse of that relationship was shown for carbohydrate and sucrose levels.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Children with the lowest serum triglyceride levels had the highest vegetable fat intakes.
Frerichs et al., 1977	Bogalusa, Louisiana 4,081 children 2-1/2-14 years old 70% white 30% black Acceptability of hemoglobin levels defined by National Nutrition Survey Standards.	White children had significantly higher levels of hemoglobin than black children at all school ages. Prevalence of low hemoglobin was 7.4% in white children and 21.9% in black children. Prevalence of deficient hemoglobin was 0.7% among white children and 3.1% in blacks. Significant racial differences persisted for children from similar socioeconomic groups.
Frerichs et al., 1976	Bogalusa, Louisiana 3,446 children 5-14 years 63% white 37% black	Mean value of serum cholesterol for whites was 162 mg/dl and for blacks was 170 mg/dl. The difference is statistically significant. The values follow normal distribution curves for both races. No consistent differences in serum cholesterol levels between males and females were found. Mean triglyceride values were 73 mg/dl for whites and 61 mg/dl for blacks. The curve is skewed toward high values. Triglyceride values increase with age, but only slightly in blacks. Cholesterol levels decrease at puberty, particularly in boys.
Gregor et al., 1978 Comment: Sample was not representative of any population.	Northwest Indiana Females Grades 6-8 183 in the fall 184 in the spring 178 of above studied in both fall and spring	Zinc content of subjects' hair samples were higher than content reported in adults. No subjects were classified in poor zinc status based on Strain's (1966) criteria. By statistical analysis, zinc levels in hair and serum samples inversely correlated.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		All had hair zinc concentrations greater than 100 mcg/gm. Hair zinc levels were greater in the fall than in the spring ($p < .001$); however, no differences in dietary zinc intake were noted between the two seasons. Serum zinc levels: 3% had less than 70 mcg/100ml. Zinc in hair and in serum were inversely related ($p < .05$). Females' height, weight, age and dietary intakes were not significantly correlated to hair or serum zinc levels. Copper concentration in serum and hair samples were not significantly correlated. 4% had serum copper below 70 mcg%, indicating poor nutritional status. These subjects were not significantly different from the rest in regard to dietary intakes, height, weight and age. Mean hematocrit values were 40%. 1% of the subjects had values below 36%, considered low by HANES standards. Hematocrit levels were inversely correlated with iron intake. Mean hemoglobin values were 13.8 gm%. No subject had a low hemoglobin value according to HANES standards.
Ward et al., 1958 Comment: No information was provided on how sample was drawn, or on socioeconomic status.	Washington State, Snohomish and Yakima Counties 124 females 124 males 15-16 years old Serum ascorbic acid values were compared to the classification of Lowry et al. (1945).	There were no significant differences between 15-16 year olds or between regions for serum ascorbic acid values. There was a significant difference at the 5% level between the sexes. 25% of the females and over 33% of the males had serum ascorbic acid levels of 0.4 mg% or less.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
Hodges & Krehl, 1965 Comment: An extensive study of a large sample, 2,045, for whom data are available on only a small number (252) for all aspects. The total sample is stratified and random; however, no information is provided as to how the actual sample compares to the total sample.	Iowa 124 females 128 males Grades 9-12	Approximately 15% had serum cholesterol values over 200 mg%. However, cholesterol values declined as body weight increased. There was a positive correlation between cholesterol levels and fatfold thickness of the scapula ($p < .05$). There was a substantial difference in serum triglyceride levels by sex; these varied directly with sugar intake and with increases in body weight. The rate of riboflavin excretion in the urine was high. 17% of the females had hemoglobin concentrations below 12 g/dl.
Johnston et al., 1978	Minneapolis 753 Native Americans 390 females 363 males 22 days to 16 years old	Hematocrit levels were found to be within normal range, but with lower means than whites in the Ten State Survey; however, they do not deviate from means for blacks in the same survey.
Karp et al., 1976	North Philadelphia 143 black children	10% of the sample were identified as being "at risk" on the basis of anthropometric measurements. This group had a mean hemoglobin concentration of 11.7 g/dl compared to 12.4 g/dl for 20% of the sample that was found to be well nourished ($p < .05$).
Kirksey et al., 1978 Comments: (1) Some cells have as few as five subjects; (2) Subjects are volunteers; (3) No socioeconomic status data provided.	Northwest Indiana 127 females 61 in the spring 66 in the fall 12-14 years old	31% of the subjects were found to have some vitamin B_6 inadequacy as measured by plasma erythrocyte alanine amino-transferase (E-ALAT). Vitamin B_6 levels in erythrocyte did not appear to be a sensitive indicator of vitamin B_6 nutritional status. Age or the onset of menarche did not appear to influence E-ALAT measurements.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		13% were judged to be in poor vitamin B_6 status (plasma E-ALAT index).
Koh, 1980	Southwest Mississippi 200 households 304 individuals Black 81 females 6-17 years old 86 males 6-17 years old	Analysis was conducted for the following substances: hematocrit, hemoglobin, red blood cells, white blood cells, serum iron, calcium, albumin, globulin, vitamin C, glucose, cholesterol, thiamin, and riboflavin. Results that were statistically significant for the 6-17-year-old population ($p < .05$) were glucose and riboflavin by sex. Statistically significant differences by age for the total sample ($p < .05$): hematocrit for females, hemoglobin for males, vitamin C for males, cholesterol, thiamin, and riboflavin for both sexes. Conclusion: There are differences by age and sex, more research needed.
Lauer et al., 1975	Muscatine, Iowa 2,346 males 2,483 females 6-18 years old 96.4% white 2.8% Spanish-American 0.6% black 0.1% American Indian 0.1% Oriental	Serum cholesterol values were similar at all ages for both males and females. Mean was 182 mg/dl. Triglyceride values showed little difference according to sex. The mean at age 6 was 72 mg/dl and at 18 108 mg/dl. Significant increases in the mean levels occurred with age for both males and females ($p < .001$).
Lee, 1978 Comments: (1) Data analysed here were collected in 1973; (2) Sample is not representative of the population by age and sex; (3) Income information collected only from those willing to provide it.	Central Kentucky 118 teenagers 12-19 years old 34 white males 51 white females 12 black males 21 black females	More blacks had lower values of the following measurements than whites did: hemoglobin ($p < .05$) serum iron transferrin saturation serum vitamin C. Mean hemoglobin and hematocrit values for males are higher than for females ($p < .01$); however a higher proportion of males of both

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Mean family income: $12,445 for whites $ 7,824 for blacks	races had values below acceptable range than females. Whites, both males and females, had higher hemoglobin concentrations than blacks ($\underline{p} < .05$) and a higher proportion of blacks had unacceptable values. Black females had significantly lower means for serum iron ($\underline{p} < .01$) and for percent saturation of transferrin; they also had the highest incidence of unacceptable values in percent saturation of transferrin. Serum total protein levels of black males were significantly higher than for other groups ($\underline{p} < .05$); not serum albumin values, however. More whites had unacceptable levels of vitamin A and carotene than blacks ($\underline{p} < .01$) Serum cholesterol and beta lipoprotein levels were significantly higher for blacks of both sexes than for whites ($\underline{p} < .01$).
Lopez et al., 1980 Comment: No statistical tests done.	210 adolescents 13-19 years old 109 males 101 females 126 Hispanics 58 blacks 26 whites Low income Method: erythrocyte glutathione reductase activity Normal activity coefficient values range from 0.9 to 1.2	Activity coefficient values ranged from 1.21 to 2.20. Conclusion: 23.3% were found to have deficient riboflavin levels. Ethnic breakdown in deficient levels: 34.5 blacks 19.8 Hispanics 15.4 whites.
Lopez et al., 1975	New York City 100 children	8 children of school age, 3 females and 5 males, showed biochemical evidence of riboflavin deficiency.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	2-1/2 days to 14 years old Low income	None showed clinical indications of deficiency. 4 of the children were below the 50th percentile for weight.
Myers et al., 1968 Comment: Part of the Boston Nutrition Survey, all subjects are from one district.	Boston 297 children 9-13 years old 227 black 70 white Approximately equal number of males and females Low income Values were categorized using standards of the Interdepartmental Committee on Nutrition for National Defense (1963).	22% of the subjects had low or deficient hemoglobin levels; significantly more blacks than whites ($p < .01$), also more females than males ($p < .05$). With increasing age there was an increase in values for males, especially black males. 13% fell into the "low" category for hematocrit. Cholesterol values were lower on the average than in other reported studies. 91% had values under 200 mg%; 9% were above; group mean was 161 mg%. Mean values for serum vitamin A and carotene fell in the lower part of acceptable ranges. 20% of the subjects had low urinary thiamin values. Urinary niacin levels were acceptable. All subjects had high and acceptable levels of urinary riboflavin with the exception of 5 black children in the low category. There were significantly lower values for nitrogen excretion for blacks than for whites ($p < .01$). A decrease in nitrogen excretion with increasing age was shown.
O'Neal et al., 1976 Comment: Both black and white individuals were included in the study; however, data were given for whites only, though conclusions were drawn by ethnicity.	Missouri, statewide 201 white children 5-17 years old 112 males 89 females Broad income group	Male mean hemoglobin values rose from ages 5-17. Female mean hemoglobin values rose from ages 5-12, with a very slight increase from 13-16. Over 30% of males between ages 6 and 9 had low or deficient hemoglobin and serum iron levels.

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Classification for low and deficient values were derived from Ten State Survey guidelines.	11.4% of females 6-9 years old had low or deficient hemoglobin values (this age group had the highest incidence of low hemoglobin for all females). Low serum iron was found in 25% of females 6-9 years old and 17.5% of 10-16 year olds. Conclusion: Iron-deficiency anemia as assessed by dietary iron intake, hemoglobin level, hematocrit concentration, and serum iron levels exists in this population. While a higher proportion of males had low or deficient hemoglobin levels, a higher proportion of females had iron intakes below 50% of the RDA.
Prothro et al., 1976 Comment: The sample is very small; of the total sample of 102, only 27 are adolescents. It is often not possible to select what findings pertain to the adolescent age group.	Macon County, Alabama 27 adolescents 13-18 years old 19 black 8 non-black	Hemoglobin levels were significantly lower for black females ($p < .05$); otherwise there were no differences by sex or ethnicity. Serum vitamin B_{12} levels were significantly higher in females than in males ($p < .01$), and were higher for blacks. Serum carotene levels were higher for blacks than for non-blacks ($p < .05$) and were higher for the black male than for the black female ($p < .05$). Serum folate levels were higher for non-black males than for non-black females ($p < .05$).
Reisinger et al., 1972 Comment: National Nutrition Survey Standards (NNSS) are used for comparison ("National Nutrition Survey" was an early name for the Ten State Nutrition Survey).	Lower Greasewood, Arizona Navajo 6-16 years old Sample size variable	Percent of subjects having unsatisfactory values Males 6-12 13-16 Hemoglobin % 0 0 NNSS 11.5g/dl 13.0g/dl N 98 30 Hematocrit % 2 10 NNSS 36% 40% N 98 30 6-12 13-16

Table III-6. Surveys that Include Biochemical Techniques as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Serum Iron % 16 9 NNSS 50mcg/dl 60.mc/dl N 43 11 Transferrin Saturation % 51 22 NNSS 20% 20% N 41 9 Females 6-12 13-16 Hemoglobin % 3 6 NNSS 11.5g/dl 11.5g/dl N 101 34 Hematocrit % 4 3 NNSS 36% 36% N 101 34 6-12 13-16 Serum Iron % 23 21 NNSS 50mcg/dl 40mc/dl N 40 14 Transferrin Saturation % 30 36 NNSS 20% 15% N 37 14 Serum vitamin C and vitamin A levels were all at or above acceptable levels. Serum protein levels were also within normal ranges. Conclusion: No specific malnutrition, though marginal iron deficiency is noted.
Van de Mark & Wright, 1972 Comments: (1) No ethnic or socio-economic information provided.	Birmingham, Alabama 114 pregnant females 12-17 years old 40 non-pregnant females 12-15 years old From the University of Alabama Medical Center Interdepartmental Committee on Nutrition for National Defense was used for standard.	For both pregnant and non-pregnant females average values for hemoglobin, hematocrit and whole blood folate were below acceptable standard. The average hemoglobin was 12.9 g%; 8% of the subjects had a level of less than 11 g%.
Williams et al., 1979	New York City 76 1st graders	22% of the children had cholesterol values of 180 mg/dl or higher; mean value was 158 mg/dl.

C. *What Growth and Development Problems Have Been Identified by Anthropometric Measures of Nutritional Status Among School-Age Children?*

Nutritional anthropometry is concerned with the variations in the physical dimensions or the composition of the human body at different levels or degrees of nutriture. In this section we first discuss undernutrition, as indicated by retardation of growth in height and weight. Ethnic differences in growth patterns are also considered. This discussion is followed by an examination of conditions of overweight and obesity as measured by weight-for-height and fatfold thickness.

Undernutrition

Growth is influenced by biological determinants such as sex, ethnicity, and parental size, as well as by environmental factors such as nutrition, socioeconomic status, and level of education. Growth is usually evaluated by weight, height, and arm circumference measurements, which are compared to standards appropriate for age and sex. Height-for-age is considered to be a reflection of long-term nutritional status, while weight-for-height reflects short-term changes.

Mild chronic undernutrition evidenced by low height-for-age or low weight-for-age was reported in several surveys. The Nutrition Surveillance Program (Nichaman & Lane, 1979) noted that more than 10 percent of 6 to 18 year olds, mainly males, fell below the 5th percentile for height-for-age. Retardation in weight status was found in the Ten State Survey. Table III-7 shows the percentages of children aged 6 to 10 who fell below the 15th percentile for weight. The percentages are approximately twice the percentages from the Stuart-Meredith reference data, presumably due to the low socioeconomic status and poor nutrition in the Ten State sample. Marked height retardation was also found in the sample, with 25 to 45 percent of children who fell below the 15 percentile from the Stuart-Meredith reference data.

Table III-7. Percentage of 6- to 10-Year-Old Children Below 15th Percentile for Weight of Stuart-Meredith Standard in the Ten-State Nutrition Survey.

Age (Years)	Percentage of Children below 15th Percentile			
	Male		Female	
	White	Black	White	Black
6	27	27	35	37
8	39	32	32	31
10	34	45	20	27

(Source: Schaeffer, 1976. p. 379)

Effects of Socioeconomic Status. All of the national surveys and several local studies found an association between growth retardation and socioeconomic status. The Ten State survey noted that more children from low socioeconomic households were below standards for height and weight than children from upper income households. For example, one of the reports from this survey states that

> Evidence of retarded growth was apparent in children from low-income families. Relative to what would be expected for a well-nourished population, two times as many black and three times as many white children in families living in poverty were below the 15th percentile for accepted American standards for height. There was a progressive decrease in the prevalence of undergrown children with increasing family income. Children in certain age groups from higher income families were advanced in their heights by as much as a year over children from lower income families (Garn & Clark, 1976).

These same trends were reported in HANES (Abraham et al., 1975). Both boys and girls above poverty level were, on the average, taller than children below poverty level. In 14 of 17 comparisons for children at each age level from 1 to 17, boys in the income group above poverty were taller than boys in the group below poverty. They also showed a greater average increase in height over the entire age range. The average difference in the increase in mean height between males in the two income groups was 3.9 cm (1.5 in).

At ages 6 to 11 years, girls in the income group above poverty were also taller on the average than girls who were below the poverty level. At 12 to 17 years the same trend was seen, except for ages 14 and 17. The greatest difference was at age 16, where the mean height for girls in the above-poverty group was 4.8 cm greater than the mean height for girls who were below the poverty level.

The differences in weight status by income were greatest in the older age groups of children studied in HANES. In general, the magnitude of the differences in mean weight according to income was somewhat less than the differences for height, but the direction of the differences was the same, again favoring the high-income group (Abraham et al., 1975).

Effects of Race. Several studies in the United States show that school-age children from ethnic minority groups have different patterns of growth and development than white children. When socioeconomic status is controlled, black children are taller and heavier than white children of the same age and sex (Abraham et al., 1975; Garn & Clark, 1976; Myers et al., 1968; Barr et al., 1972; Lee, 1978). Black children of both sexes have longer leg and upper-arm lengths, which account for the overall difference in body size (Garn & Clark, 1976; Foster et al., 1977). It has also been found that blacks mature faster than whites according to skeletal development (Malina, 1971). HANES data show that skeletal maturity in blacks of both sexes is advanced by up to four months compared to whites (Abraham et al., 1975).

Black females also tend to reach menarche earlier than white females and have an earlier growth spurt (Foster et al., 1977; Verghese et al., 1969).

In spite of these differences, black children often show signs of growth retardation. For example, Meyers et al. (1968) found low height-for-age in both sexes of black children and low weight-for-age among males in Boston. In this study, 42 percent of black males and 30 percent of black females aged 9 to 13 were below the 25th percentile for height using the Boston Standards. Forty percent of the black males were below the 15th percentile for weight.

Other studies listed in Table III-8 failed to show significant amounts of growth retardation among black children. However, most of the studies used standards such as the Stuart-Meredith charts and the Boston Standards, which were derived from samples exclusively composed of white children. (See Chapter II.) Because of genetic differences in growth and development as well as in final adult stature between blacks and whites, the extent of growth retardation among black children may be greater than reported by the surveys.

Few comparisons have been made between children from other ethnic minority groups. Samples in the national surveys have not permitted examinations by races other than white and black. Consequently, all of the information on children from other racial/ethnic backgrounds (e.g., Hispanic, Asian, Native American) comes from small, local surveys whose samples are not necessarily representative of the populations studied.

The mean height of Mexican-Americans aged 15 to 19 years was reported to be at the 34th percentile of the Iowa growth charts by MacKinney in a statement before the Senate Select Committee on Nutrition and Human Needs in 1969. In a study by Burroughs and Huenemann (1970), of 86 Mexican-American children aged 0 to 9 years in Coachella Valley, California, 50 percent of the girls and 43 percent of the boys were below the 25th percentile of the Stuart-Meredith growth charts. Low weight-for-age and height-for-age were more recently reported by Zavaleta and Malina (1980) for 1,269 Mexican-American children aged 6 to 17 years in Brownsville, Texas. The mean heights and weights of these children were at approximately the 25th percentile of the U.S. Health Examination Survey (HES) reference data.

Another recent study (Duncan et al., 1979) compared the growth of 4,167 Spanish-surname Denver children and 2,322 non-Spanish-surname children, 5 to 13 years of age, who resided in the same neighborhoods and attended the same schools in low-income areas. Spanish-surname children were consistently lighter and 1-3 cm shorter than Anglos. The authors believe that socioeconomic factors are probably more important than genetic factors in accounting for the differences.

Different groups of Native Americans have also been studied. Thirty-eight percent of Navajo children, aged 5 to 14, in Lower Greasewood, Arizona, were found to be under the 10th percentile of the Stuart-Meredith norms (Reisinger, et al., 1972). Eight (21%) of 39, 5-year-old White Mountain Apache children were below the 10th percentile of the Stuart-Meredith charts in height (Owen, et al., 1972).

Overweight and Obesity

Health professionals as well as lay persons tend to use the terms "overweight" and "obese" interchangeably. However, these terms are not synonymous. Overweight is usually defined as being heavier than ideal weight. When individuals are more than 20 percent above their ideal weight for height, age and sex, they are commonly referred to as obese. However, since the excess weight may be due to muscle or fat, a more technically accurate definition of obesity is an excess of body fat. The amount of body weight composed of fat can be estimated by laboratory techniques, such as

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underwater weighing, or by measurements of fatfold thicknesses at one or more sites on the body. These measurements are discussed more fully in Chapter II.

A number of standards have been used to calculate ideal weight for height, sex and age. Examples include the Metropolitan Life Insurance Company tables (Society of Actuaries, 1959), the Iowa Growth Charts (Stuart & Meredith, 1946), the Boston Growth Charts (Stuart et al., 1951), and the National Center for Health Statistics Growth Charts (NCHS, 1976). As explained in Chapter II, these standards are based on population distributions and may not necessarily correspond with the values for weight and body fat that promote optimal health.

Obese individuals store excessive amounts of fat. Many possible causes for this have been postulated, including excess energy intake, low energy output, and improper food habits. Each of these will be briefly discussed.

Excess Energy Intake. Food consumed yields energy. If more food is ingested than is needed, the excess energy will be converted to fat. It does not appear to be important whether the energy is consumed as carbohydrate, fat or protein.

Low Energy Output. It is not clear whether or not the absolute energy consumption of obese individuals is higher than that of normal-weight individuals. Decreased energy output may be as important as actual energy intake in the promotion of obesity. However, not many surveys investigate this aspect of obesity, possibly because of methodological difficulties. Apart from differences in the level of physical activity, there are also individual differences in basal metabolic rate, but the possible contribution of these metabolic differences to the pathogenesis of obesity is also unclear.

Improper Food Habits. Another possible factor in obesity is the number of times per day a child consumes food. School children between 10 and 16 were found to be fatter if they consumed only three meals per day than if they ate five to seven meals (Fabry et al., 1966). Family eating patterns appear to be important in the genesis of obesity; habits of overeating may be acquired early in life through socialization. Frank et al. (1979) found no significant relation between meal frequency and fatfold, but did find that 10 year olds who had 6 to 8 eating times had higher "body mass indices" (WT/HT^2) than ones who had either 1 to 5 or 9 to 12 eating times.

Prevalence of Obesity in School-Age Children

Several surveys of school-age children show that obesity, as measured by triceps fatfold, is not uncommon. Depending on sex and race, the prevalence of obesity in the Ten State Nutrition Survey was between 6 and 8 percent for children 6 to 10 years of age and 10 to 13 percent for children 11 to 17 years of age (Garn & Clark, 1976). Being an overweight or obese child and/or adolescent has implications for adulthood, since overweight children are more likely than normal-weight children to become overweight adults (Abraham & Nordsieck, 1960; Weil, 1977). The reason obesity may be important for a population of any age is that excess fat aggravates or is associated with a variety of medical problems such as arteriosclerosis, diabetes, hypertension, arthritis, and sudden death.

There are general indications in the literature that females are more prone to obesity than males during middle childhood (Myers et al., 1968; Lee, 1978). All children tend to gain weight during puberty; however, some lose it in later adolescence while others do not. The factors associated with weight retention after puberty seem to be related to socioeconomic status, race, and sex.

Effects of Socioeconomic Status. The Ten State Survey found that in general children from higher income groups were fatter than children from lower income groups through puberty (Garn & Clark, 1976). However, from late adolescence through adulthood there was a reversal of this trend among females, and females from lower income groups were fatter than females from higher income groups.

The same general pattern is seen in HANES data. Triceps fatfold values of males below the poverty level were lower than those of males above poverty in all but two age groups (15 and 17 years). Girls below the poverty level also had lower average triceps fatfold values in all but two age groups (12 and 14 years). HANES does not present prevalence data on obesity in children, but prevalence data on adults confirm the Ten State Survey findings that income differences among older females are reversed. At 20 to 44 years of age, approximately 10 percent of below-poverty males and 11 to 17 percent of above-poverty males are obese, but among females, 18 to 25 percent above poverty and 25 to 35 percent below poverty are obese (Abraham et al., 1975).

The local studies shown in Table III-8 have produced more variable results on the relationship between socioeconomic status and obesity. For example, Stunkard et al. (1972) studied over 3,000 white children from three Eastern cities and found that at ages 6 to 18, more children of low socioeconomic status were obese than children of upper socioeconomic status.

It is difficult to reconcile these differences. They may be due to the geographic and racial characteristics of the samples and to the standards used to determine obesity.

Effects of Race. In HES cycles I and II, HANES cycle I, and TSNS, white children were found to have greater fatfold thicknesses than black children at 6 to 11 years of age. Thus, while black children are, on the average, heavier than white children when sex, age and income are controlled, less of their total body weight is composed of fat and more is composed of lean body mass. This difference persists into adolescence and adulthood among males. In the HANES data, white males have greater triceps fatfold values than black males at all but three ages (14, 15, and 17 years) throughout the school-age range. The pattern is not as well defined for girls. Triceps fatfold values for white females exceeded those for blacks at ages 7 to 8, 11, 13, and 16, but at ages 9, 10, 12, 14, 15, and 17 black females had greater average triceps fatfolds than whites (Abraham et al., 1975). At ages 20 to 44, more white males were classified as obese than black males, but more black females were classified as obese than white females.

Several of the local surveys also found that white children have more body fat than blacks (Rauh & Schumsky, 1968; Malina, 1971; Foster et al., 1977). There is less available information about other racial/ethnic groups. In two studies (Hampton et al., 1966; Christakis et al., 1968), Chinese adolescents were found to have smaller fatfold measurements than whites and blacks. Johnston et al. (1978) found that the average weights of Native American children in Minneapolis were greater than the national averages found in HES. Native American males also had greater triceps fatfolds than the HES sample, but the average fatfold value among Native American females was less than the HES values.

Zavaleta and Malina (1980) recently measured height, weight, triceps fatfold, and arm circumference of low-income Mexican-Americans in Brownsville, Texas. They found that Mexican-American children had consistently lower heights and weights than HES reference data for American children, confirming the Ten State results for this population group. Their estimates of midarm-muscle-mass medians were also lower than HES medians. The authors indicate that these results may be due to their diet, "which tends to be adequate in calories but less satisfactory in protein."

Discussion

Anthropometric measurements reveal that there are children in the United States who suffer from chronic undernutrition. The prevalence of undernutrition is greatest among low-income children. Available evidence suggests that perhaps two to three times the expected number of low-income children are below the 5th percentile for height, and twice the expected number are below the 15th percentile for weight. The exact magnitude of the problem is unknown, however, since the extent of these conditions might be greater if race-specific standards were available.

The increasing amounts of data on overweight and obesity indicate that this may be a more serious problem than undernutrition for children and adolescents. During school age, the prevalence of obesity is approximately 8 to 13 percent, but the figures are much larger among adults. There is evidence that obese children have a high probability of carrying their excess fatness into adulthood, where it complicates or promotes a variety of medical conditions. The prevalence of obesity differs by sex, race and socioeconomic status, but the factors responsible for the observed patterns are not clear.

Studies that used anthropometric measurements of school-age children are summarized in Table III-8, which follows.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NATIONAL SURVEYS		
HEALTH AND NUTRITION EXAMINATION SURVEY (HANES)		
Abraham et al., 1975 Comments: (1) Risk of bias because response rate failed to meet the requirement of the original probability design; (2) Estimates are based on weighted observations; data inflated to the level of the total population; (3) Preliminary findings only; (4) No statistical significances calculated between income and ethnic groups.	10,126 persons, 1-74 years old white 73% black 16% 2,112 children, 6-17 years old 1,050 males 1,062 females 2 income levels: above and below poverty, 20% at or below poverty	Males in the income level above poverty were taller than males in the level below poverty. The difference is 3.0 cm for males 6-11 and 3.3 cm for males 12-17. Age 15 is an exception; the reverse trend was found. Females 6-11 from the income group above poverty were taller than females in the income group below poverty. The difference ranged from 0.3 cm to 3.8 cm. This trend continued for females ages 12-17, except at ages 14 and 17. The largest difference in height occurred at age 16. Males ages 16-17 in the income level above poverty are heavier than males in the level below poverty, with an exception at age 8. 6-11 year olds showed a 1.5 kg difference; 12-17 year olds a 4.1 kg difference.
HEALTH EXAMINATION SURVEY (HES)		
Zack et al., 1979	U.S. Health Examination Survey, Cycle II and III 2,177 children examined initially when they were 6-11 years old and again 2-5 years later when they were 12-17 years old. Body fatness was measured by fat-fold thickness. Children with measurements in the top 20% of the sample were considered obese.	Rank-order correlations between the two examinations for each race-sex group were highly significant. ($p < .001$). 68% to 77% of the sample classified as obese in childhood were also obese in adolescence. 39% to 52% of the sample classified as lean in childhood remained lean in adolescence. The relationship between childhood and adolescent fatness was independent of stature, skeletal and sexual maturation, and economic status. Conclusions: Childhood fatness is the most important predictor of adolescent fatness.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NUTRITION SURVEILLANCE SYSTEM		
Nichaman & Lane, 1979 Comment: This report covers only five states in the CDC system and the sample is not representative of the states or or any specified subpopulation.	2,740 males 2,890 females 6-17 years old Criteria used for low weight and stature by CDC National Surveillance System are: Low height for age: height for age less than 5th percentile of the NCHS standards (NCHS, 1976). Low weight for age: weight for age less than the 5th percentile of a person of the NCHS standards (NCHS, 1976). Low weight for height: weight for height less than the 5th percentile of a person of the NCHS standards (NCHS, 1976). High weight for height: weight for height greater than the 95th percentile of a person of the NCHS standards (NCHS, 1976).	Low height for age was found in 6.9%, 10.4%, and 10.9% of the males aged 6-9, 10-12, and 13-17, respectively. Low height for age was found in 5.2%, 7.9%, and 9.7% of the females aged 6-9, 10-12, and 13-17, respectively. Low weight for age was found in 5.5%, 9.3%, and 9.7% of males aged 6-9, 10-12, and 13-17, respectively. Low weight for age was found in 4.9%, 6.8%, 8.3% of the females aged 6-9, 10-12, and 13-17, respectively. Low weight for height was found in 5.7%, 5.0% and 4.5% of males aged 6-9, 10-12, and 13-17 respectively. Low weight for height was found in 5.2%, 5.6% and 9.9% of the females aged 6-9, 10-12, and 13-17 respectively. Conclusions: More than 5% of the children were short for their age which indicates growth retardation probably due to chronic mild undernutrition.
TEN STATE NUTRITION SURVEY (TNSN)		
Martin & Beal, 1978 Comments: (1) The sample is not nationally representative; (2) The sample was not restricted to low-income or below-poverty-level population; (3) Analysis of the results often groups ages in a way that makes it impossible to draw conclusions for school-age population; (4) The data are provided in raw form, with no interpretations offered; (5) No statistical differences were calculated.	Low-income ratio states: Kentucky, Louisiana, South Carolina, Texas, and West Virginia High-income ratio states: California, Massachusetts, Michigan, New York, and Washington 40,847 persons 16,000 pediatric age Obesity was determined by triceps fatfold values and Seltzer-Mayer (1965) standards.	Blacks were taller than whites until adolescence; no differences due to income levels. White children were slightly heavier and had larger subcutaneous fat measurements than blacks. Black children had more lean body mass, white children had more fat as proportions of total body weight. Obesity was more common in white male adolescents than in other groups.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Height for age was evaluated by Stuart-Meredith (1946) standards.	Children in high-income ratio states were taller, heavier, and fatter than children from low-income ratio states. More children were rated short for age from low-income than from other groups.
Garn & Clark, 1976	TSNS (as described above)	White males tended to be fatter than black males. Black school-age females were leaner than white females. Children from higher SES were fatter than children from lower SES. Males from higher SES were fatter than males from lower SES, especially during adolescence. There was a rapid increase in weight during puberty; however, males lose the fat required during puberty and females do not. By age 17, children of 2 obese parents are 3 times as fat as children of 2 lean parents.
Garn & Clark, 1975	TSNS (as described above)	No evidence of starvation-level malnutrition, but differences in growth and development by race were apparent. After correcting for socioeconomic status, "...black boys and girls tended to be taller, had larger skeletal mass, had greater bone density, and had skeletal and dental advancement" (p. 316).
LOCAL SURVEYS		
Abraham & Nordsieck, 1960 Comments: Social class data not provided.	Hagerstown, Maryland Approximately 2,000 children, ages 10-13, were measured for weight in 1937-39. Repeat measurements were made in 1958 on 120 adults, 62 males and 58 females.	For each sex, overweight children tended to become overweight adults more often than children of average weight ($p < .001$). 86% of overweight boys were overweight as adults.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Overweight defined only by weight and height Weight standards from life insurance data (Society of Actuaries, 1959).	42% of average weight boys became overweight as adults. 80% of overweight girls were overweight as adults. 9% of average weight girls became overweight as adults.
Barr et al., 1972 Comment: None of the differences were tested for statistical significance.	San Francisco 7,500 children 5-14 years old Black, white and Oriental	Blacks were taller than whites up to age 12. At ages 13 and 14 there were no significant differences. Black children were heavier than white children. Oriental children were shorter and weighed less than white children. Conclusion: Separate standards for weight and height are recommended for different ethnic groups.
Bell, 1971 Comment: Findings include all children because school-age population cannot be separated from the rest.	North Nashville, Tennessee 50 black children Average age 9.6 years (includes infants) 58% male 42% female Low income Boston standards for height and weight.	Distribution of weights and heights of subjects followed standard curves. Only 4% were classified as obese.
Christakis et al., 1968 Comment: The sample is very small for analyses by ethnic group.	New York City 642 children 10-13 years old 56% females 44% males 64% Puerto Rican 14% Chinese 10% black 8% white 4% other Low income	White children had significantly higher fatfold values (15.4 mm) than other children ($p < .01$). Chinese children had the lowest mean fatfold of all the children (12.3 mm). 11.4% of the subjects were considered obese, as measured by fatfold and corpulence.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
Daniel & Rowland, 1969 Comments: (1) No ethnic breakdown is provided; (2) Criteria for obesity are not defined.	Birmingham, Alabama 268 black and white children 11-18 years old 125 males 145 females Low income Height and weight were plotted on Wetzel grid.	None were classified as growth-retarded. More females were obese than males.
Duncan et al., 1979 Comments: No income information collected; subjects attended schools in low to low-middle middle income areas of Denver.	Denver, Colorado 4,167 low-income, Spanish surname 2,322 low-income, non-Spanish surname 5-13 years old, male and female	At all ages, Spanish-surname children were shorter and weighed less than non-Spanish-surname children; there is a statistically significant difference between Spanish- and non-Spanish-surname children ($p < .0001$). Comparison with an earlier (1970) study of children from the same city of middle to upper-middle income found both Spanish- and non-Spanish-surnamed subjects from low-income schools were smaller than children from middle to upper income areas. Conclusion: Socioeconomic status is more important than ethnicity in the etiology of growth discrepancy.
Foster et al., 1977 Comment: Anthropometric data were found to be similar to HES (NCHS, 1970, 1972, 1973, 1974), but sexual maturation data are at variance with the national sample, since in the U.S. black females reach menarche sooner than white females. However, the opposite was found to be true of Bogalusa girls except at age 10.	Bogalusa, Louisiana 3,524 children 5-14 years old; represents 93% of this age group in the county 37% black 63% white	Black and white males were similar in height and weight. Black females averaged 2 kg heavier than white females ($p < .005$) and were 2.8 cm taller. Among white children, females were shorter than males (except at ages 10-12) and were lighter (except at ages 8 and 10-12). Generally the opposite relationship existed for blacks. For all race-sex groups, there was a slight decrease in median ponderosity ($W/H3$) with increase in height.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Generally girls were less ponderous than boys of corresponding height. Ponderous girls reached sexual maturity sooner than non-ponderous girls. Black children, especially females, had longer upper arm lengths than whites by 0.7 cm ($p < .0005$); however, arm circumference of whites exceeded that of blacks by 0.3 cm ($p < .05$). Fatfold mean values for whites were 2.5 mm larger than for blacks.
Gregor et al., 1978 Comments: (1) The sample is not random; (2) the differences are not tested for statistical significance	Northwest Indiana Females grades 6-8 183 in the fall 184 in the spring Data collection took place in the fall of 1975 and the spring of 1976.	Mean heights in the fall = 156±8 cm, in the spring = 157±8 cm. Mean weights in the fall = 48±12 kg, in the spring = 52±30 kg.
Hampton et al., 1966	Northern California city 4-year longitudinal study of high school students 9th grade: 458 males 519 females 12th grade: 403 males 404 females Approximately: 60% white 30% black 10% Oriental Anthropometrics were measured by 11 body circumference and 6 bone diameter measurements and height and weight	Black males and females had a higher percentage of body fat than whites or Orientals. White females had a higher percentage of body fat than Oriental females in the 9th and 11th grades ($p < .05$). Oriental females differed more in their measurements from other females in the 9th, 10th and 11th grades than in the 12th grade. Female body fat increased from the 10th to the 11th grade and decreased from 11th to 12th grade. "Lean" and "somewhat lean" females were taller than other females. "Obese" males were taller than other males, particularly in the 9th grade, the difference becoming progressively less later.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Obesity was defined as the upper 10 percent of the subjects with the most body fat, by sex.	Black females had significantly higher percent of body fat than white females ($p < .01$), and Oriental females ($p < .01$) in all 4 grades. The prevalence of obesity ranged from 11% to 14% for males over the 4-year period and from 11% to 17% for females. Males grew more rapidly than females. Their growth slowed down during the 11th and 12th grades, while the percentage of body fat increased significantly.
Hodges & Krehl, 1965 Comment: An extensive study of a large sample, 2,045, of whom data is available for all aspects on only a small number (252). The total sample is stratified and random; however, no information is provided as to how the actual sample compares to the total sample.	Iowa 124 females 128 males Grades 9-12 Iowa growth standards for height and weight	Compared to the standards, the 1965 sample was taller and heavier. Body weight positively associated to increases in triglyceride levels ($p < .05$) and increases in fatfold thickness under the scapula ($p < .05$), and with blood pressure levels ($p < .05$).
Johnston et al., 1978 Comment: The cells are too small for meaningful conclusions to be drawn.	Minneapolis Native Americans 1,309 persons 22 days to 17 years old Sample size for conclusions: Males, 6-17, 53 Females, 6-17, 92 Males above 14, 32 Data compared with HES (NCHS, 1972, 1973) findings.	The Minneapolis Native American data yielded the following significant findings: Body weight, on the average, was greater than the HES sample. Males above 14 years of age did not have lower means stature than the HES sample. Native American males 6-17 years of age had greater average triceps fatfolds ($p < .001$) than HES sample. Native American females, on the other hand, had smaller average fatfolds than ($p < .001$) the HES sample.
Karp et al., 1976	North Philadelphia 143 black children Kindergarten and 1st grade,	10% of the children were below the 10th percentile for height and weight and had triceps fatfolds below 70% of standard.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	5-8 years old Low-income area For height and weight: Stuart's standards (Habicht et al., 1976) For triceps fatfold: Hammond (1975) Uses triceps fatfold as a means of defining potential malnutrition.	Conclusion: Growth retardation is nutritional and not environmental.
Lauer et al., 1975 **Comment**: Obesity as risk factor has to be compared to adult standards.	Muscatine, Iowa 2,346 males 2,483 females 6-18 years of age 96.4% white 2.8 % Spanish-American 0.6% black 0.1% American Indian 0.1% Oriental Weights were compared by computing the median weight for height of all subjects by age and sex; the median weight was assigned a value of 100%. For fatfold, Seltzer & Mayer (1965) criteria were used.	At all ages 23% of the subjects had relative weights of at least 110%. In the 14-18 year age group, 13.1% of the males, and 13.6% of the females had relative weights of 120% or more, and 7% of the males and 8.6% of the females had relative weights of 130% or more. Skinfold values showed that 16% of the subjects were obese. Boys had a progressive mean increase in fatfold thickness from age 6 to 18 ($p < .001$); girls had a contrastingly greater uniform increase per year ($p < .001$). The mean value of the ponderal index at all ages and by sex was constant at 12.9. 5% showed a ponderal index of less than 12.0. 3.8% showed less than 11.6.
Lee, 1978 **Comments**: (1) The data reported here were collected in 1973; (2) Sample is not representative of the population by race or sex; (3) Standards used were old (Sargent, 1963; Seltzer & Mayer, 1965) and and not applicable to these populations (Malina, 1966); (4) Income data were collected only from those who were willing to disclose it.	Central Kentucky 12-19 years old 31 white males 5 white females 12 black males 2 black females Mean family incomes: $12,445 white $ 7,824 black	The mean weight and height for black males under 16 years of age were significantly greater than of those of white males of the same age group, ($p < .01$). At age 16 and above, no such differences were found. Black females were less active than white females ($p < .01$); activity differences by ethnicity among males were not significant. Weight and height were significantly associated with age in both sexes ($p < .01$).

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Triceps fatfold, calf circumference, and arm circumference were associated with body weight ($p < .01$). The prevalence of overweight by the standards of Sargent (1963) was: 40% for white females 43% for black females 12% for white males 10% for black males The prevalence of obesity by the standard of Seltzer and Mayer (1966) was: 27% for white females 28% for black females 12% for white males 8% for black males The mean heights and weights for females of both ethnic groups did not show statistically significant differences.
Malina, 1971 Comment: Significance tests were not reported.	Philadelphia 825 children 6-13 years 242 black males 244 black females 191 white males 148 white females Two measurements taken on each subject over a 1-year period. Fatfold measurements taken at three sites: triceps, subscapular, and midaxillary.	White children had more subcutaneous fat at all measuring points than black children; the difference was most marked at the triceps site. Subscapular and midaxillary measurements correlated more highly with each other than with triceps fatfolds.
Myers et al., 1968	Boston 299 children 9-13 years old Approximately equal numbers of males and females 69% black 28% white 3% other	More children were in the lower percentiles than expected; for example: Among the population studied, 59% of the white males, 42% of the black males, 57% of the white females, and 30% of the black females were below the 25th percentile for height. As to weights, more black females were in the 91st percentile or higher, and more white females were

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Low income Boston standards for height and weight Seltzer & Mayer (1965) for fatfold	in the 25th percentile and lower, than expected. 55% of white males and 40% of black males were below the 25th percentile for weight. In general black children were taller and weighed more than whites. Based on fatfold, 8% of the children were obese: more females than males were obese, more whites than blacks, and more 10-11 year olds than other age groups.
Prothro et al., 1976 Comments: Sample size is much too small to be divided into ethnic and sex categories.	Macon County, Alabama Low income 27, 13-18 year olds 19 black 8 non-black Total sample has 102 2-85 year olds, 40 males 62 females	Mean body weights of 13-14-year-old males exceeded the National Research Council (1968) standards by 25 pounds; 12-14-year-old females exceeded it by 30 pounds. The 15-18-year-old males had weights near the NRC standards, but the females of this group exceeded their standards by 10 pounds. In terms of height, both females and males of the 13-14-year-old group exceeded their NRC standards by 2 or 3 inches. The 15-18-year-old group had similar heights to the NRC standards. Black adolescent males, 13-19 years of age, were significantly [illegible] than the other three sex-ethnic groups ($p < .05$).
Rauh & Schumsky, 1968	Cincinnati, Ohio 1,573 children 1,130 repeat measurements one year later 6-17 years old Equal number of males and females 65% white 35% non-white	Average values for fatfold thickness were greater for whites than for non-whites. Fatfold measures for males peaked between 11 and 13 years, indicating a fat spurt. Female fatfold thickness showed a continuous increase until age 15 for whites and age 13 for non-whites, when there was a deceleration in growth of fatfold values. The stability of distributions of measurements 1 year later was high.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
Reisinger et al., 1972	Lower Greasewood, Arizona 245 Navajo children 5-14 years old 120 males 125 females Boston and Iowa standards for height and weight.	82% of the 5-14 year olds were below the 50th percentile for height and 76% of the 5-14 year olds were below the 50th percentile for weight. There was a delay in skeletal maturation ranging from 14% in boys to 30% in girls, or 1-1/2 to 2 years compared to the standards. Conclusion: Slower rate of growth and development may be due to nutrition.
Ruppenthal & Gibbs, 1979	Petaluma, California 399 children K to 3rd grade AMA-NEA (Meredith & Knott, 1963) Standards for height and weight; 12 of the 41 overweight children enrolled in an exercise program.	41 subjects were 10% or more over appropriate weight for height. (1) Only six subjects in the exercise class attained normal weight; (2) No sex, ethnic, or socioeconomic data. Conclusions: Exercise class at school aids in the reduction of obesity in children.
Stunkard et al., 1972	3 Eastern cities 3,344 white children 5-18 years old 40% female 60% male 11 schools 2,310 from upper socioeconomic status, 857 from lower socioeconomic status, 167 not clearly classified as to socioeconomic status. Obesity was determined by using Seltzer & Mayer (1965) criteria, and another one where 10% of each sex in the total population that had the thickest fatfolds were defined as obese--23 mm for females and 18 mm for males. Similarly, thinness was defined as the 10% of each sex with the thinnest fatfold; 8mm for females and 6mm for males.	At age 6, 29% of low SES females were obese compared with 3% of high SES females. This trend continued to age 18 ($p < .001$). 40% of the males at age 6 from low SES were obese, compared to 25% of the males from high SES. This trend continued to age 18 ($p < .001$) with the exception at age 12 when high SES males had a higher percentage of obesity than low SES males. At age 6, 15% of the high SES females were thin as compared to 4% of low SES females. This difference continued to age 12, when both groups showed a decreasing prevalence of thinness. In males there was no clear trend relating SES and thinness. For both sexes, socioeconomic status and thinness correlated ($p < .02$).

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
Verghese et al., 1969 Comment: Most of the survey dealt with 1-5 year olds.	Washington, D.C. 2,632 black children 3 months to 17 years old (556 over 5 years old) 53% female 47% male low income Boston standards for height and weight.	Height curves were similar to curves from studies of white children. After age 6 the children were slightly taller than standards. Males and females had equal average weights from 7-10 years of age. From ages 10-14 females were heavier than males by 2 to 5 kg. After age 14 the females' weight gain decelerated and the males' weight gain accelerated so that males became heavier than females.
Williams et al., 1979	New York, New York 95 1st-graders, predominately white Upper SES 2 schools, 10 miles apart Seltzer & Mayer (1965) criteria for fatfold. Excessive defined as equal to or above the 85th percentile for age. Height compared with HANES means for age and sex.	Only 2 children weighed as much as 120% of the mean. 18% of the children, 16 males and 1 female had excessive fatfold values. Ethnic differences were slight.
Zavaleta & Malina, 1980	Brownsville, Texas 1,269 Spanish-surnamed 619 males 650 females 6-17 years old Elementary and junior high students from low socioeconomic area; high school students from all areas of city Weight: with clothes, then adjusted by 1 lb for regular clothes, 1/2 lb. for gym clothes Height. Left arm circumference. Triceps fatfold: obesity and leanness criteria were 85th and 15th percentiles respectively from Tecumseh Project (Garn, 1977) and 9th and 10th percentiles respectively from NCHS (1972, 1974).	Mean heights and weights of girls similar to Mexican-American girls in Texas phase of the TSNS but Brownsville boys are taller and heavier at ages 16-17. Median weight at or below 25th centile of HES reference data. Median weights between 25th and 50th centiles of HES reference data. Median triceps fatfolds of boys similar to HES data through age 14 but higher at ages 15-17. Girls were equal to or lower than HES data through 11 years, but higher through age 16 and the same at 17. Arm muscle area consistently less at all ages.

Table III-8. Surveys that Include Anthropometric Measurements as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Estimated midarm muscle circumference, muscle area, and fat area derived from arm circumference and triceps fatfold.	Median arm fat areas lower than or equal to HES medians at most ages. About 7% are classified as obese by NCHS standards but only 6.3% of the girls and 4.5% of the boys by Tecumseh standards. About 3% are classified as lean by NCHS standards, but 29.1% of the girls and 33.8% of the boys by Tecumseh standards.

D. *What Clinical Signs of Nutritional Problems Have Been Identified Among School-Age Children?*

Clinical observations are of limited value in the early diagnosis of nutritional deficiencies; by the time clinical signs are apparent, severe malnutrition already exists. Furthermore, they are not often reliable as a diagnostic tool because of their subjective nature.

Not many clinical signs of nutrient deficiencies have been detected in the United States. Findings of surveys of school-age children are summarized in Table III-9. The Ten State Survey reported that for children over 6 years of age, 3 to 4 percent had an enlargement of the thyroid gland suggestive of iodine deficiency and 3 to 4 percent also had changes in the oral cavity, suggestive of vitamin B and/or C deficiencies. Among adolescents, 4 percent exhibited clinical signs of vitamin C deficiency and 5 percent, vitamin A deficiency (Owen & Lippman, 1977). Some local surveys reported similar findings (Christakis et al., 1968; Myers et al., 1968).

Other clinical aspects of nutritional assessment involve screening for conditions that have a possible nutritional basis. Some of these conditions do not appear until late adulthood; however, investigators believe that their genesis is in childhood. A few of these conditions of interest for the school-age population will be briefly mentioned here; however, a comprehensive discussion is not possible in this report.

Atherosclerosis

In adults the risk of developing coronary artery disease is directly related to the level of serum cholesterol, blood pressure, and relative weight (Marks, 1960). There are, however, no longitudinal data that relate childhood levels of serum lipids, blood pressure, and relative weight to later risk factors for atheromatous disease in adult life.

Many investigators believe that the genesis of atherosclerosis is in childhood. However, in the United States, it is difficult to show a correlation between dietary fat and cholesterol intake and plasma cholesterol levels (Weidman et al., 1978). Some researchers believe this is due to the fact that the dietary intake of these substances in the United States is already so high that a reduction in intake will not have the same effect on plasma levels as it does in areas where the diet is lower in these substances.

Hypertension and Other Cardiovascular Conditions

Neither HANES nor the Ten State Survey reported blood pressure levels. However, hypertension and other cardiovascular conditions were assessed in Cycles II and III of the Health Examination Survey (NCHS, Series II, No. 166, 1978). Overall, the surveys estimate that 2.4 percent or about 570,000 children aged 6 to 11 years have a significantly abnormal heart or other circulatory conditions. The corresponding rate is nearly double for children 12 to 17 years of age. The prevalence of definite hypertension, using the adult standard of systolic pressure over 160 mm Hg and/or diastolic pressure over 95 mm Hg, was less than 0.1 percent among 6- to 11-year-old children and less than 1 percent among 12- to 17-year-old children. However, children 12 to 17 years of age with other significant cardiac conditions had a much higher prevalence of hypertension (13%) than children in the same age group with no abnormal findings.

Cardiovascular conditions, including hypertension, were more prevalent among children living in the South than in other regions of the United States, and among children living in rural areas than among children living in urban locations. In all geographic areas blacks exhibited more cardiovascular conditions than whites. The prevalence of cardiovascular conditions showed an inverse relationship with income: the highest rates were among children from families earning less than $5,000 per year. This pattern was more consistent for females than males and for whites than blacks.

The local surveys tend to find a higher prevalence of hypertension among school-age children than the Health Examination Survey. However, not all studies used the HES standards for determining high blood pressure. The Muscatine study (Lauer et al., 1975) found that a considerable number of children 14 to 18 years old had blood pressure levels above the norms for their age. Over 8 percent of the children had elevated systolic pressures; 12 percent had elevated distolic pressures; over 4 percent had elevated readings for both systolic and diastolic pressure. Hodges and Krehl (1965) also reported high systolic pressures among teenage boys in Iowa. Christakis et al. (1968) found increased diastolic blood pressure levels in 33 percent of low-income white children in New York. The prevalence among whites was higher than in other ethnic groups. In contrast, Lee (1978) found higher systolic pressures among black than white teenagers in Central Kentucky.

In Evans County, Georgia, in a seven-year follow-up study, Heyden et al. (1969) found that adolescents who had blood pressures greater than 140/90 mm Hg originally, and higher than 160/95 mm Hg at the time of a second investigation, did not fare as well as their cohorts with lower blood pressure. After seven years, of the eighteen "high risk" adolescents, two had already died of cerebral hemorrhages, four had heart disease, and many of the rest had other cardiovascular complications.

Several studies found a relationship between blood pressure levels and body weight in adolescents (Christakis et al., 1968; Hodges & Krehl, 1965; Lee, 1978). As a matter of fact,

> the increased prevalence of higher levels of blood pressure in the children with elevated relative weights shows that the relationship of obesity to blood pressure has its origins in childhood (Lauer et al. 1975).

Lauer et al. (1975) proceeded to recommend that 14 to 18 years olds should be screened for adult-level risk factors, which they define as:

Serum cholesterol above 220 mg/dl;
Systolic blood pressure over 140 mm Hg;
Diastolic blood pressure over 90 mm Hg; and
Relative weight over 130 percent.

Lactose (Milk) Intolerance

This term refers to a person's inability to digest milk properly because of a deficiency of lactase, an enzyme produced in the intestines. Some researchers consider this a serious enough problem to advise certain groups such as blacks and Asians, who are most susceptible to lactose intolerance, to avoid drinking milk. However, others believe that small amounts of milk can be consumed by individuals who are lactose-intolerant (Stephenson et al., 1977). A complete discussion of this controversy cannot be provided here; however, the Protein Advisory Group of the United Nations (1972), the Food and Nutrition Board of the National Academy of Science (1972), and the Committee on Nutrition of the American Academy of Pediatrics (1978) all conclude that the problem is not severe enough to rule out the consumption of milk by children. According to Graham, lactose intolerance

> does not represent a nutritional problem in this country. Most of those who have age- and race-dependent low intestinal lactase activity could drink eight ounces of whole milk at each meal with impunity and full nutritional benefit (1975:296).

In spite of this assertion, lactose intolerance among school-age children merits further investigation.

Dental Disease

Dental caries is the most widespread dental disease in children. It is an infectious disease which is dependent on sugar, or sucrose, to support the growth of acid-producing bacteria which decay the teeth. The amount of sugar consumed appears to be less important than the form in which it is consumed or the frequency with which it is consumed. Sticky sweets consumed between meals are the greatest promoters of dental caries. However, sugar is not the only factor. Other factors such as dental hygiene are related to the prevalence of tooth decay.

The Ten State Survey found a high rate of decayed, missing, and filled (DMF) teeth among school-age children (Center for Disease Control, 1972). White children were shown to experience more dental caries than black children. By age 17, almost 40 percent of white children's teeth were carious, while the rate for black children was approximately 25 percent. Myers et al., (1968) surveyed 228 black children and 94 white children and also concluded that black children have fewer dental caries.

The Ten State Survey found that children from low-income and high-income states had roughly the same DMF scores. However, more of the carious teeth of children from low-income states were unfilled, indicating that the dental care available to these children is less adequate than the care available to children in high-income states.

In the Ten State Survey, the rate of dental disease was unrelated to total sugar and carbohydrate consumption, but was associated with between-meal eating of carbohydrate-rich foods for all ethnic groups in the high-income states and for black children in the low-income states.

Discussion

Not many clinical signs of nutrient deficiencies have been detected in the United States. However, there are conditions that have nutritional components. Some of these conditions appear in childhood, such as dental caries. The surveys that assessed the dental status of this population found a considerable amount of carious and filled teeth. There are also a number of nutrition-related conditions that are believed to start in childhood, but do not exhibit themselves until adulthood. Some of these, e.g., hypertension and atherosclerosis, are being investigated for possible associations between childhood nutrition and the probability of oneset of disease in later life.

Methodological Issues

Before concluding this chapter, there are several methodological issues that should be considered when examining surveys of the nutritional status of school-age children. These issues are concerned with design, analysis, and the standards against which nutritional assessments are compared.

Design

The design issues include sampling, time of data collection, and age composition of the sample.

Sampling. Surveys often do not provide information on how the sample was obtained--whether it was random, purposive, stratified, or obtained by a combination of several methods. Self-selection may also bias the sample if the subjects are volunteers. One cannot generalize from a study that does not clearly define the sampling method and the population. This is a fault of several of the local studies.

Small sample size is another problem for many nutrition surveys. Sample sizes in nutrition surveys vary from fewer than ten to several thousand subjects. Conclusions from small, local studies are particularly vulnerable because of small sample size, which leads to low power and large standard errors for parameter estimates.

The problem of small sample size is magnified for 24-hour recalls, because of the double sampling of both individuals and days. That is, a 24-hour recall must be considered as being sampled from the universe of possible 24-hour recalls that might have been obtained on different days. A particular recall may not be representative of a person's usual intake, and if the sample of individuals is small, the average intake for a group may have an unacceptably large standard error. It is commonly said that 24-hour recalls are suitable for getting averages for groups of 50 or more persons (Keys, 1979). Thus, even when the total sample is large, the number of subjects may not be sufficient for analyses of subgroups. This problem is discussed at greater length in Chapter II. One way to reduce the variability of 24-hour recall data is to obtain more than one recall per person. Prothro et al. (1976) collected three 24-hour recalls per child, and Hampton et al. (1967) collected four seven-day food records per subject. However, the samples for these studies were so small that even multiple recalls did not assure adequate data for estimating the proportion of the RDA met by the diet when the samples were divided by age, race, and sex. Some biochemical measures are also subject to considerable day-to-day variability, but anthropometric and clinical measures are affected less by it.

Timing of Data Collection. The time period when data collection took place is usually not stated in reports of studies, making chronological comparisons impossible. It is useful to investigate changes in nutritional status over time, but without the date of data collection it may be difficult to determine the order in which studies were conducted. The date of publication is a general clue, but researchers often collect data several years prior to publication.

Age Composition of Sample. All of the research reported here involves school-age children ranging in age from 5 to 18 years, but many surveys include only a part of this age range. When looking at the nutritional status of school-age children, specific nutrients may have been investigated only for a particular age range. Thus, for some nutrients, values are available for only one age group and little is known about the status of children of different ages. Examples are the studies conducted on folic acid, vitamin B_6, and zinc. When researchers or reviewers summarize the data for a nutrient, conclusions are often drawn for the total population, while data may be available for only portions of it. Even when raw data are available by age group, subjects from different age groups are often grouped together for analysis.

Analysis

Analytical problems often arise from the non-comparability of groups, and the neglect of certain factors such as the factors influencing absorption of minerals and the fortification of food.

Ethnic and Socioeconomic Comparisons. These comparisons are not as simple as they may appear. Middle-income individuals may often have low-income origins, which means that their early nutrition was influenced by diets from low-income households. When making socioeconomic comparisons, it should be taken into consideration that over the years the family's income may have fluctuated a great deal. Furthermore, ethnic groups are often not reliably distinguished; thus, growth and biochemical differences that are attributed to them may be biased due to classification errors. Many surveys draw their samples from a particular geographical location, which does not necessarily provide ethnic and socioeconomic homogeneity, yet the data are analyzed as if the sample were homogeneous. As an example, the Ten State Nutrition Survey refers to "Spanish Americans." This subgroup included Mexican-Americans from states like Texas and California, as well as Puerto Ricans from New York City, and there are wide differences in the background and food habits of the two groups.

Socioeconomic status in surveys is often designated only as "above" or "below" a poverty level. These distinctions are crude, since there is wide variability within these categories. This type of classification underestimates or inflates the magnitude of the differences, because a large proportion of the families below or above the poverty line could be considerably poorer or wealthier than the rest. Also, what is considered "poverty-level" income varies from year to year as conditions affecting the cost of living change.

Absorption of Minerals. One aspect that is frequently ignored in dietary data analysis is the fact that there are synergistic effects in food digestion. It makes a difference which foods are consumed together. A good example of this is iron and vitamin C: If iron is consumed with a reducing agent, such as vitamin C, a higher proportion of iron is absorbed than if it is consumed without the reducing agent. The amount ingested and the nutritional status of the individual also play a role in the amount of a mineral absorbed. A deficient individual will absorb more when a small amount is consumed than an individual with satisfactory status will absorb when a larger amount is consumed. Therefore, while dietary intakes may appear to be insufficient, biochemical analysis could reveal normal tissue and storage levels. Deficiencies in both calcium and iron are considered by some investigators to be problems for school-age children, but the evidence depends on whether dietary, biochemical or clinical assessments were used.

Fortification. Many changes in regulations and practices concerning food fortifications have taken place in the last several years. These regulations and practices vary from state to state. As a result, large national companies may fortify their products to meet the most stringent state's requirements; however, foods processed or prepared for consumption within a state often meet only that state's standards. Food consumption surveys are not always able to determine the extent of fortification of foods.

Vitamin C is a good example of a nutrient that has been extensively used for fortification. Many beverages and other foods are now highly fortified with this vitamin. Iron, another nutrient of concern, has also been added to bread and cereals. Many surveys were completed before some of the fortification practices were implemented; therefore, intakes from these surveys are not necessarily comparable to current intakes.

Standards

The problem with standards that are used for assessing dietary, biochemical and anthropometric measurements have been discussed in Chapter II. However, at this point it is worthwhile to reiterate some problems with the RDA. There are several aspects of the RDA that must be considered when assessing nutrient intake data.

A margin for safety has been built into the RDA which raises the allowance to a level that exceeds most people's requirements. When a dietary survey reports, for example, that over 90 percent of the respondents have deficient intakes of a nutrient, the term "deficiency" applies only to the relationship between intake and the standard. It does not necessarily imply adverse biological consequences for the respondents whose intakes are below the standard. However, from the viewpoint of health promotion, it may indicate the proportion of individuals in the population whose diets could be improved.

The second problem with using the RDA as standards for dietary surveys is the fact that they are revised every few years, which results in changes for some nutrients. The allowance for vitamin C, for example, was reduced between 1968 and 1974, but increased for 1980. Studies that analyze their data using the most recent RDA might note deficiencies that would not be shown with an earlier or later RDA. Therefore, changes in standards must be taken into consideration when comparing the results of surveys carried out at different times.

There are also problems such as excessive nutrient intakes, which are not usually addressed in surveys but can have an impact on the health of the school-age population. Sometimes one finds nutrient intakes that are several hundred times the RDA--often called "megadoses." There are no standards set for the safe upper limits of most nutrients.

The common attitude that excessive intakes of the water-soluble vitamins (ascorbic acid and the B group) are not harmful is becoming less acceptable. For example, animal experiments reveal that when females are fed greater amounts of ascorbic acid than necessary, it can precipitate scurvy in the offspring who consume normal levels of vitamin C (Cochrane, 1965). Dangers may also arise from large intakes of other vitamins and minerals.

At the present time there is a great awareness in the United States of vitamins as "positive" substances and, therefore, some people believe that if small amounts of a substance are essential then very large doses may be curative. Unfortunately, the possible harmful effects of megadoses of vitamins and minerals do not appear to be as great a concern as inadequate intakes. Yet, some children are consuming very large amounts of vitamins A and C, zinc, and possibly other nutrients as well. At this time, not as much research has been undertaken to examine the prevalence of excessive intakes as has been with deficient intakes. There appears to be a great need to investigate the possible harmful effects of long-term excessive ingestion of all vitamins and minerals.

CONCLUSIONS

In spite of many inherent problems in the interpretation of data from nutrition surveys, there are a number of consistent findings in both national and local surveys that have been conducted on children. An attempt will be made here to state some conclusions about the nutritional status of the school-age population of the United States, summarizing information from the four types of nutritional assessment techniques: dietary data analysis, biochemical analysis, anthropometric measurements, and clinical signs.

At the present time, dietary intakes of the following nutrients are of concern in the school-age population of the United States: vitamins A and C, calcium, and iron. Intakes of vitamin B_6, magnesium, folic acid, and zinc have also been shown to be low in some subgroups, but these nutrients have not been studied extensively. Energy intake, both in terms of inadequate and excessive amounts is also a potential problem. The major nutrition-related conditions found in the school-age population appear to be obesity, iron-deficiency anemia, and dental disease.

Energy Intake. The data on energy intake show that problems exist at both ends of the intake spectrum, with undernutrition as well as overnutrition. Children from low-income homes are more likely to have deficient intakes than children from high-income homes. Deficient or excessive intakes occur when the amount ingested is not consonant with body size and the amount of energy expended.

Vitamin A. This vitamin is frequently cited as one that is deficient in the diet of children, and biochemical measures show evidence of low values in some subgroups. However, there is little indication of functional disability of any type in the school-age population that may have been caused by vitamin A deficiency. Heald (1975) suggests that the standard for vitamin A is too high for some age groups.

Vitamin C. Intakes of vitamin C among children are found to be low in some surveys. Nevertheless, serum levels are generally found to be adequate. There has been much fortification with vitamin C since many of the surveys were done. Most fruit-flavored beverages, for example, have been fortified, along with cereals and other food items. Vitamin C deficiency is unlikely in normal school-age children. However, there is some vitamin C loss in processing, cooking and storage of food.

Calcium. There are no clinical signs of calcium deficiency in the school-age population, even though dietary intake, especially among teenage girls, is consistently found to be inadequate. This mineral is a significant nutrient because deficient intakes throughout life may contribute to osteoporosis (i.e., demineralization of bones). However, Gopalan and Rao (1979) state that if the RDA for vitamin D is met--which appears to be the case for almost everyone in the United States--it may not be necessary to consume the amount of calcium recommended by the dietary allowances. However, possible imbalances between calcium and phosphorous in the diets of children are a potential problem. Until more is known about the consequences of low intakes, the National Research Council is of the opinion that the RDA should not be reduced (National Research Council, 1980).

Obesity. Obesity appears to be prevalent in western societies. It carries with it increased risk of diseases such as diabetes mellitus, heart disease, and high blood pressure. The chief causes of obesity are overeating and inactivity. Once these habits are acquired, they are difficult to overcome.

Obesity is gradually becoming the most important school-age nutrition problem in the United States. Overweight children are more likely to become overweight adolescents (Zack et al., 1979) and overweight adults (Abraham & Nordsieck, 1960; Weil, 1977). There are relationships between the prevalence of obesity and sex, race and socioeconomic status. The Ten State Nurtrition Survey (1972) found that children from low-income states were thinner than children from high-income states, but that in late adolescence there is a reversal of this trend among females. HANES data show that during adulthood the group with the greatest prevalence of obesity is low-income black females.

Iron Deficiency Anemia. Iron deficiency is the most prevalent cause of anemia in children, but the condition can also result from other causes, such as deficiencies of vitamin B_{12} and folic acid, and genetic anomalies (e.g., the sickle cell trait). It is commonly believed that iron deficiency is a serious problem in the school-age population and many surveys have shown this to be the case. The exact prevalence, however, has been difficult to establish. There are several reasons for this: (1) iron intake data alone are not adequate to determine the severity of a deficiency because the form of iron and the presence of vitamin C influence absorption and utilization;

(2) hemoglobin and hematocrits--which are measured most frequently in surveys of iron status--may not be sensitve and reliable indicators of iron deficiency, especially for black children; and (3) factors other than iron deficiency that could cause anemia are seldom ruled out.

Serum iron, transferrin saturation and serum ferritin give a more accurate picture of iron status than hemoglobin and hematocrit, because they reflect the amount of iron stores. Serum ferritin is a relatively new test that has not been used in the national surveys. HANES did not find a high percentage of low serum iron values among school-age children, but did find that 8 to 18 percent had unacceptable values for transferrin saturation. The highest percentage of unacceptable values was found among teenagers. More low-income children had unacceptable values, but there was no pattern related to race.

Dental Disease. Dental caries is the most widespread dental disease in children. Some surveys note a high prevalence of uncorrected dental problems, or signs of past dental problems such as missing and filled teeth, in the school-age population. Dental disease results from a combination of genetic and environmental factors. The factors that are manipulable in this population are dental hygiene and nutrition. Apparently, inadequate dental hygiene and the frequent consumption of carbohydrate-rich between-meal snacks greatly contribute to the poor dental status of school-age children. (Center for Disease Control, 1972).

Summary

It is apparent that deficiency diseases (such as scurvy, pellagra, and beriberi), which used to be prevalent problems of school-age children, no longer exist to any great extent. However, there are still nutrition-related conditions that affect the school-age child. Some conditions such as mild chronic undernutrition, dental caries, overweight, and iron-deficiency anemia are apparent during the childhood years. Others such as obesity, high serum cholesterol, and high blood pressure may contribute to more long term problems. The causes of these problems, and the demographic and socioeconomic factors associated with them, require further clarification through continued research.

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
NATIONAL SURVEYS		
HEALTH AND NUTRITION EXAMINATION SURVEY (HANES)		
Abraham et al., 1975 Comments: (1) Preliminary findings only; (2) Estimates are based on weighted observation, data inflated to the level of the total population; (3) There is a risk of bias because response rate failed to meet the original probability sample; (4) No statistical significances calculated between income and ethnic groups.	2,112 children 6-17 years old 1,050 males 1,062 females Approximately 70% white and 30% black 20% at or below poverty level	In general, clinical signs indicating high or moderate risks for nutritional deficiencies were infrequent. Signs where percent prevalence exceeded 10% were: Follicular hyperkeratosis, 6-11-year-old blacks below the poverty level. Thyroid enlargement, Group I, 12-17-year-old blacks above the poverty level. Positive Chvostek's sign (Calcium-Phosphorus imbalance)--12-17 year olds, white and black in income levels above and below poverty. Black children showed generally higher prevalence than whites for deficiency signs for vitamins A, C, D, iodine, and calcium-phosphorus imbalance. Children from families below poverty showed higher prevalence than above-poverty-level children for deficiencies of vitamins A and C, and for calcium-phosphorus imbalances.
TEN STATE NUTRITION SURVEY		
Center for Disease Control, 1972	Children from 10 states plus New York City (see Martin & Beal, 1978)	Conclusion: Black and Spanish-Americans had more untreated and decayed teeth than whites did.
Martin & Beal, 1978 Comments: (1) Geographically, the survey was limited; it excluded the Western and Plains states; (2) The sample was not restricted to low-income or below-poverty-level populations; (3) Ages are often grouped, making it impossible to draw conclusions for the school-age population; (4) No statistical differences calculated.	40,847 persons 16,000 pediatric age Low-income ratio states: Kentucky, Louisiana, South Carolina, Texas, and West Virginia High-income ratio states: California, Massachusetts, Michigan, New York, and Washington	There was little evidence of severe malnutrition. The few positive non-specific signs in skin, hair and eyes were inconclusive. Thyroid enlargement was least prevalent in whites, and most prevalent in Spanish-Americans from low-income-ratio states (unrelated to urinary iodine excretion). The rate of decayed, missing and filled teeth increased with age in all income and ethnic groups.

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		The state of dental health was unrelated to sugar and carbohydrates eaten at meals, but was related to between-meal consumption of carbohydrates by all ethnic groups in high-income-ratio states and to blacks only in low-income-ratio states.
LOCAL SURVEYS		
Brunswick & Josephson, 1972 Comments: (1) Part of a larger survey; (2) Self perception of health problems by adolescents with examination, 74% of those interviewed were also examined; (3) Data collected 1968-70.	New York, Harlem 421 children 12-15 years old Black	The most prevalent of all health problems among adolescents were dental problems. 20% of both sexes had vision and eye problems. 16% of both sexes had respiratory heart and blood pressure problems. 10% had skin and complexion problems, twice as many females as males. 7% of both sexes had nutrition (mainly obesity) problems. 4% had anemia, twice as many females as males. Conclusion: Adolescents' own health appears to be of great concern to them.
Christakis et al., 1968	New York City 642 children 10-13 years old 56% female 44% male 64% Puerto Rican 14% Chinese 10% black 8% white 4% other Low income	Clinical findings showed that 5% of the subjects demonstrated follicular hyperkeratosis, 4% angular fissure, 6% gingival redness and hypertrophy, 7.1% diffusely enlarged goiter (with females having three times the frequency of males) and 6.3% cardiac murmurs (males having twice the frequency of females). 4.5% of the females and 2.4% of the males had systolic blood pressures of 140mm Hg and over. 5% of the sample had diastolic pressures of 90mm Hg and over. 4 times more obese children showed systolic pressures of over 140mm Hg than non-obese children.

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		33% of the white children had diastolic pressures of 85mm Hg or more, a highly significant difference with other racial groups. No difference was noted by sex on dental ratings; however, Chinese children had lower ratings than other ethnic groups.
Clarke et al., 1978	Muscatine, Iowa 8,909 school children 5-18 years old 816 examined repeatedly over a 6-year period 50% male 50% female	13% of the sample had systolic and/or diastolic blood pressure levels in excess of the 95th percentile for their age and sex group. 6-year correlations were .30 for systolic and .18 for diastolic blood pressures.
Frank et al., 1978	Bogalusa, Louisiana 185 children 9-11 years old 65% white 35% black	Mean systolic blood pressures for males were 98mm Hg and for females, 99mm Hg. Diastolic blood pressure levels averaged at 61mm Hg for all. Subjects with the highest systolic levels had diets with the lowest sucrose content; subjects with the highest diastolic pressures had diets highest in potassium.
Garza & Scrimshaw, 1976	Boston 99 children 4-9 years old 69 black 30 white	The following percentages of black children were found to be lactose intolerant by the standard lactose tolerance test: 11% of 4-5 year olds, 50% of 6-7 year olds, and 72% of 8-9 year olds. However, no child was found to be intolerant to 240 ml (approximately one cup) of milk. The daily milk intake of lactose-tolerant and lactose-intolerant black children was not statistically significantly different; however, daily milk intake of all 8-9-year-old black and white children was (p < .01).

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Conclusion: "...existing milk programs for young children need not be limited by considerations of primary lactose intolerance" (p. 195).
Hard et al., 1958 Comments: (1) No information on how the sample was drawn; (2) No information on socioeconomic status.	Washington State, Snohomish and Yakima Counties 124 females 124 males 15-16 years old The gingiva and the epithelium of upper arm were observed by biomicroscopic examination and by physical exam, and gums were photographed for indices of ascorbic acid nutritional status.	Average biomicroscopic scores for arm and gingival lesions indicate a "slight" ascorbic acid deficiency. Significant correlation found for chronic gingival lesions and serum ascorbic acid in Yakima females. Otherwise no correlation were significant for lesions, serum ascorbic acid, vitamin C intake, regions and sexes. Photographs showed results similar to the biomicroscopic scores. Physical exam showed no abnormalities for Snohomish females, "mild" recession of the interdental papillae in 10% of Snohomish males, and among the Yakima subjects, 25% had "mild" to "moderate" signs of swelling, recession of the interdental papillae and recession at the dental margin.
Hodges & Krehl, 1965 Comment: 2,045 teenagers were examined, but data are reported on only 252.	Iowa Grades 9-12 128 males 124 females	Systolic blood pressures were slightly higher in males than in females. Blood pressure was positively associated with a rise in triglycerides and an increase in body weight ($p < .05$). There was a positive relationship between blood pressure and fatfold thickness of the arm ($p < .05$), but negative with fatfold thickness of the scapula ($p < .05$).
Larson et al., 1974 Comments: (1) No information provided as to how clinical signs were determined; (2) Sample sizes were not reported.	Lower Rio Grande Valley, Texas 137 children 2-9 years old Mexican-American	40% were found to have 2 or more cavities, 16% had 5 or more cavities. The following clinical signs were observed: Follicular hyperkeratosis, hypertrophied tongue papillae, rib beading, widened wrists, pallor, anemia, angular stomatitis, liver enlargement, B complex deficiency, and generalized under-nutrition.

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S) COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
		Conclusion: Many signs of nutrient deficiencies exist in this population.
Lauer et al., 1975	Muscatine, Iowa 6-18 years old 2,345 males 2,483 females 96.4 white 2.8% Spanish American 0.6% black 0.2% American Indian 0.1% Oriental Hypertension defined as systolic 140mm Hg or diastolic 90mm Hg or above.	Ages 6-9 had no blood pressures at hypertensive levels. 8.9% of the subjects 14-18 years old had systolic pressures above 140mm Hg; 12.2% had diastolic pressures of 90mm or above, and 4.4% had both systolic and diastolic readings in the hypertensive range.
Lee, 1978 Comments: (1) Data were collected in 1973; (2) Sample is not representative of the population by race or sex; (3) Income data were collected only from those willing to disclose it.	Central Kentucky 12-19 years old 72 females 46 males 85 white 33 black Mean family income: $12,445 white $ 7,824 black	Systolic blood pressure above 135mm Hg was observed in 23% white males, 14% of white females, 58% of black males and 19% of black females. Black males' systolic blood pressure levels were statistically significantly higher than the other groups ($p < .05$). Systolic blood pressures were significantly correlated to body weight for both sexes ($p < .01$), to serum triglycerides in females ($p < .01$), and to beta lipoproteins in males ($p < .01$). Visible dental caries were found in 7% of whites and 18% of blacks. The prevalence of risk factors associated with coronary heart disease found in this population were: smoking, high blood pressure, elevated serum lipids, and overweight.
Myers et al., 1968 Comment: Part of the Boston survey, all subjects from a single district.	Boston, Massachusetts 211 children 9-13 years old 228 black 94 white	Dental pathology was found in 93% of the population. Black children generally had better teeth than whites. 16 children, all black, had no tooth decay. Whites had 50% more caries and 3 times as many fillings as blacks, which are significant differences ($p < .01$).

Table III-9. Surveys that Include Clinical Signs as Part of the Nutritional Assessment of School-Age Children (Cont'd)

AUTHOR(S)/ COMMENTS	SAMPLE/ METHODOLOGY	FINDINGS/ CONCLUSIONS
	Approximately equal number males and females Low income	Additional clinical findings: gingivitis, 62% dry, scaling skin, 52% follicular keratosis, 25% tongue involvement, 25% eye signs, 13% bow legs, 15% knock knees, 13% heart murmurs, 10%
Williams et al., 1979 Comments: (1) Data were collected in the fall and winter of 1977; (2) Small sample size; (3) For weight and fatfold thickness no information offered on methods of data collection; 4) Authors unable to explain large differences between the two schools.	New York City 94 first graders 5-6 years old 59 males 35 females 2 schools High blood pressure was defined by the standard of the Pediatric Task Force on Blood Pressure in Children (American Academy of Pediatrics,1977).	Only 1 child was found to have high blood pressure. Conclusion: 21% of the 95 students had 1 or more measurements that were above levels for optimal cardiovascular health. The differences between the 2 schools were large--33% in 1 school had 1 or more elevated risk factors, while only 10% in the other school showed similar elevations.